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The Role of Amino Acid in the Face of Oxidation Stress Resulting from Exposure of Strawberry Seeding to UV-C

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Abstract: The world is currently entering challenges to face climate change and find alternative means to combat the oxidative stress resulting from it. The study aims to reveal the role of amino acids in combating oxidative stress resulting from exposing strawberry seedlings to ultraviolet rays (UV-C). The experiment included two factors, the first is the concentrations of amino acids, which include (v/v) (%0%, 0.012%, 0.024). The second factor includes periods of exposure to UV-C rays, which are min/h (0,15, 30 ,60). The seedlings were sprayed with the above concentrations, then exposed to different time periods of UV-C rays, and then the seedlings were transferred to the field to monitor growth and take the required measurements. The results concluded that amino acids significantly affected most of the studied traits at a 5% probability level, except for the survival rate, leaf area of the plant (cm), number of leaves, and the percentage of potassium element. As for the period of exposure to UV-C rays, it significantly affected all traits except for the nitrogen and potassium ratio in the leaves of the plant. The interactions between amino acids and periods of exposure to UV-C rays were significant in all studied traits except for chlorophyll content and potassium content in the leaves. We conclude from our research that amino acids have contributed to protecting the plant against oxidative stress resulting from ultraviolet rays, and that the rays did not cause the death of the plant, as the plant showed resistance against UV-C rays up to a full hour. Therefore, we recommend using amino acids to combat oxidative stress.

Key words: Amino acid, Oxidation stress, Strawberry, UV-C rays, Vegetative growth.

1. Introduction

The Strawberry plant (Fragaria x ananassa) is a perennial herb and is considered a small fruit. It belongs to the order Rosales, the Rosaceae family, the Fragaria genus, and the ananassa species **(Al-Saeedi, 2000)**. The strawberry is one of the most widely cultivated fruits and is known for its good taste and rich nutritional elements **(Wang *et al.*, 2023)**. The scientific name of the plant, Fragaria x ananassa Duch., is derived from the Latin word Fragrans. Many sources indicate that its original habitat is

North America **(Otterbacher and Skirvin, 1978)**. It has several names according to languages; in English it's called Strawberry, in French Fraise, and in Italian Fragola. In Egypt, it's called Fraoula, in Syria it's called Freiz or Tut Al-Ard, and in Turkey, it's called Chillaik, which sometimes leads to it being called Shilik in Iraq **(Ibrahim, 1996)**.

Climate change has begun to negatively affect agricultural crops and plant health. Non-ideal growth conditions such as extreme temperatures, cold heat, fertilization, drought (decreased rainfall and drying winds), and soil pollution with high concentrations of salinity are the main non-biological environmental factors that can limit plant growth and development but also limit the geographical distribution of plant species and directly affect the agricultural crop **(Batista-Silva *et al.*, 2019)**. The increase in UV-C radiation in the atmosphere is one of the non-ideal conditions that cause a lot of damage to the plant, such as physiological, morphological, and genetic changes **(Hammok, 2019, Hammok and Saed, 2021, Hammok and Esho, 2022)**. Therefore, it has become necessary to protect plants from oxidative stress caused by climate changes such as UV-C radiation.

Amino acids are small repeating units linked together to form complex compounds with high molecular weights, which are proteins, and simpler compounds consisting of fewer amino acids, which are peptides. They are organic compounds that contain two active functional groups in one molecule, the basic amine group (-HN2) and the acidic carboxyl group (-COOH). The use of amino acids sprayed on the green mass of plants or added to the soil is one of the modern techniques used to improve plant growth and productivity due to their direct and significant role in increasing tissue protein content by building new types of proteins and enzymes necessary to regulate metabolic activities or activate antioxidants to resist tension and tolerate the most stressful conditions that the plant is exposed to by being exposed to cold and hot thermal shocks and drought **(Mohamed and Khalil, 1992)**. Amino acids are a biological activator that is quickly absorbed and transferred within different parts of the plant because they have a direct effect on the enzymatic activity in the plant. The basic role that the amino acid Glycine plays inside the plant is to activate photosynthesis and raise its efficiency by activating chlorophyll and green growth, as well as playing a major role in chelating some elements and protecting the plant from stresses **(Sakamoto and Murata, 2002)**.

Amino acids are a useful tool to face stressful environments and are one of the organic fertilizer techniques that affect plant growth rates and provide ready-made units for protein manufacturing that can be important enzymes for activity. These acids can be absorbed and used in different ways depending on the stage of plant growth, as they provide growth in the importance of most of the organic nitrogen in the soil and affect plant growth **(Kasouha *et al.*, 2014). Faraj and Shaker (2011)** in Iraq from their study when adding different levels of amino acids to the tomato plant such as proline, tyrosin, and arginine with irrigation water or sprayed on the green mass individually or mixed produced the highest values in green growth traits. When amino acids are sprayed on the green growth of the plant, they quickly move to all leaf cells and activate the plasma in the cells, thus providing the plant with a large amount of vital energy that completes the vital activity in it, works to compensate for the energy lost by the plant during demolition and respiration processes, and enters into the formation of nucleotides, vitamins, and growth hormones, and thus it is a basic component of living matter and protoplasm and enters into the construction of cell membranes, as well as being a source of nitrogen **(Abdul Hafiz, 2006, and Amino *et al.* 2011). Serna *et al.* (2012)** found that green growth, yield, and its components in the pepper plant improved when sprayed with a mixture of amino acids, as it led to raising the efficiency of photosynthesis, and an increase in the efficiency of antioxidants.

Low concentrations of the amino acid proline may be more beneficial for plant growth in the face of stress, as high concentrations may be toxic. Spraying the plant's green growth with the amino acid proline protects it from harmful UV-B radiation, also protects plants from various pressures, and helps in recovering from stress very quickly **(Hayat *et al.*, 2021)**.

Azimi *et al.* (2013) found that spraying amino acids such as salicylic acid on the growth and yield of wheat increased its tolerance to drought stress. Spraying salicylic acid on the plant at concentrations (1 liter / 1000 liters of water) caused water deficiency to reduce all the studied traits, but it reduced the negative effects of water deficiency on wheat. In a study of the effect of foliar spraying with different concentrations of amino acids (0.5, 1, 2.5, 5, and 10) g / liter, the researcher found that amino acids caused significant increases in the growth, productivity, and quality characteristics of the Spanish bean variety (Luz de otono variety). Superiority was achieved with the spraying treatments with the amino acid at concentrations ranging from 2.5 to 10 g / liter significantly in most of the studied traits **(Darwish, 2019). Al-Zubaidi *et al.*, 2016)** in Iraq from their study when spraying the pepper plant variety Flavio with concentrations of amino acids (0 and 400 and 800 mg liter-1) found significant increases in plant height, dry weight of the green mass, and total chlorophyll content in the leaves. Researcher, **Bingol *et al.*, 2022**, when studying the effect of temperature degrees on the anthocyanin pigment when heating strawberry juice to a degree of 90, 105, 150, found that the addition of amino acids preserved the stability of the anthocyanin pigment. Aspartic acid increased the stability of the pigment by (4.5-45.6%) at all temperatures.

The aim of this research paper is to study the effect of the role of amino acids in facing oxidative stress resulting from exposing strawberry seedlings to ultraviolet rays UV-C, as oxidative stress is one of the biggest problems facing the plant at the present time as a result of the sudden changes that occur in the climate.

2. Materials and Methods

The study was conducted in the vegetable research field of the Department of Horticulture and Landscape Engineering, College of Agriculture and Forestry, and the laboratories of the Environmental Research Center, University of Mosul, to study the role of amino acids in combating oxidative stress resulting from exposing strawberry seedlings to ultraviolet rays UV-c.

2.1. Preparation of amino acid concentrations.

Three concentrations of amino acids (Organic fertilizer) (organic matter 45%, free amino acids 12%, organic carbon 20%, organic nitrogen 4%, PH=6-4) were prepared, produced by Naturwin company. These are (0%, 0.012%, 0.024%) from the original concentration of the bottle (12%), then they were filled in sprayers and prepared for the experiment.

2.2. Planting the seedlings and irradiating them

180 strawberry seedlings of the variety (Ruby Gem Fragana x ananassa Duch) were brought and planted in pots prepared with mixed soil. Then they were treated with the above concentrations of amino acids, with 5 sprays until the seedlings were wetted with amino acids, and then they were exposed to UV-c rays for periods (zero, 15, 30 and 60 minutes) at the wavelength nm (253) using the device manufactured by the Romanian company Brayton as shown in picture number (1) in the laboratories of the Environmental Research Center. Then they were transferred to the field and the treated seedlings were planted on ridges, with 5 seedlings for each treatment and each replicate, at a distance of 10 cm between one hole and another and 20 cm between the ridges. The study was implemented with a complete random sectors design (RCBD) and with a factorial experiment (3 x4) with three replicates for each experimental unit. The data were recorded on the following traits: survival rate after treatment, plant height (cm), number of leaves, fresh and dry weight of the whole plant, leaf area, chlorophyll content a, b in the leaves and content of nitrogen, phosphorus and potassium in the leaves. All agricultural service operations were carried out from hoeing, weeding and controlling disease and insect infestations as recommended in productive fields.

2.3. Statistical analysis

The data were statistically analyzed using the **SAS (2001)** program, to test Duncan's multiple range test at a probability level of 5% **(Steel and Torrie,1980)**.

Picture number (1). Shows how to expose strawberry seedlings to UV-C rays using the ultraviolet ray device from the Romanian Braytron company.

3. Results

3.1. Variance Analysis Table

The variance analysis table (1) shows that the concentrations of the amino acid significantly affected most of the studied traits at a 5% probability level, except for the survival rate, leaf area of the plant (cm^2), number of leaves, and the percentage of the potassium element. Also, the period of exposure to UV-C rays did not significantly affect the percentage of nitrogen and potassium in the leaves of the plant. As for the interactions between the amino acid and periods of exposure to UV-C rays, they also did not significantly affect the content of chlorophyll a and potassium in the leaves

3.2. The effect of amino acids

Table (2) shows the effect of amino acid concentrations on the studied traits of the plant. It appears that the different concentrations of the amino acid did not have any significant effect on the traits of survival rate, leaf area in cm^2, number of leaves per plant, and potassium content in the leaves. However, it appears that the concentration of 2 ml/liter of the amino acid significantly affected the plant length, fresh and dry weight of the plant, total chlorophyll content a and b, and the percentage of nitrogen, protein, and phosphorus content.

3.3. The effect of exposure periods to UV-C rays

The data shown in Table 3 indicate that the exposure periods to UV-C rays significantly affected the traits studied for the plant. The treatment of exposure to rays for a period of (0 minutes) produced the highest significant values in the traits of survival rate (100.00%), leaf area (12.548) cm^2, plant length (15.548) cm, fresh and dry weight of the plant, and in the number of leaves per plant (3.744), and in the content of chlorophyll a and b. Also, no significant differences were shown between the exposure periods to UV-C rays on the rest of the studied traits, represented by the percentage of nitrogen, protein, and potassium element in the leaves.

Table (1). ANOVA table*

SOV	df	Mean square											
		X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12
Block	2	44.4444*	0.3388	400.3300	2.6507	0.7379	0.0186	0.000526	0.000127	0.0784	2.76058	0.00177	0.00743
A	2	11.1111	0.1851	438.2425*	17.6953*	1.3865*	0.0169	0.00176*	0.000168*	0.05289*	2.3346*	0.01541*	0.00429
B	3	70.3794*	45.1115*	308.8106*	44.3247*	1.5540*	1.6144*	0.00178*	0.000056*	0.02659	1.1852	0.01283*	0.00572
Ab	6	70.8897*	27.8345*	494.4895*	26.3691*	1.5154*	2.2044*	0.00183	0.000073*	0.0625*	2.6694*	0.0117*	0.00437
Error	22	44.678	4.0326	410.683	5.61955	0.5470	0.1265	0.00045	0.000048	0.05567	2.19208	0.01631	0.00943
Total	35												

*1= germination percentage (%), 2=Leave area (cm^2), 3=plant height (cm), 4=plant fresh weight (gm), 5=plant dry weight (gm), 6=leaves number/plant, 7=chlorophyll a, 8= chlorophyll b, 9= N percentage in leave (%), 10= Protein percentage (%), 11=P percentage (%), 12=K percentage (%)

Table (2). Effect of concentration of amino acid on traits of strawberry at growing season 2022*

Amino acid (mlL^{-1})	Mean											
	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12
0%	96.667 a	10.556 a	13.350 b	10.415 b	2.443 b	3.275 a	0.0013 b	0.00875a	1.255 b	7.797 b	0.666 b	0.568 a
0.012%	98.333 a	10.316a	11.750 b	10.582 b	2.441 b	3.233 a	0.0219 a	0.00342ab	1.384a	8.651a	0.596 b	0.598 a
0.024%	96.667 a	10.380 a	22.925 a	12.597 a	3.031a	3.200 a	0.00062b	0.00183b	1.346 a	8.414a	0.844 a	0.604 a

*1=percentage germination (%), 2=Leave area (cm^2), 3=plant height (cm), 4=plant fresh weight (gm), 5=plant dry weight (gm), 6=leaves number/plant, 7=chlorophyll a, 8= chlorophyll b, 9= N percentage in leave (%), 10= Protein percentage (%), 11=P percentage (%), 12=K percentage (%)

Table (3). Effect of time UV-C on traits of strawberry at growing season 2022*

UV-.(min.)	Mean											
	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12
0	100.00 a	12.548 a	15.811 a	12.253a	2.716ab	3.744a	0.0291a	0.00215c	1.302a	8.139 a	0.661 a	0.6178 a
15	93.333 b	7.416 c	24.289 a	7.913 b	2.031b	2.711c	0.00089b	0.00568a	1.270a	7.875 a	0.592 b	0.5800 a
30	97.778 b	10.106 b	11.056 b	11.871 a	2.941a	3.289b	0.0014 b	0.0077a	1.347a	8.417a	0.6156a	0.560 a
60	97.778 b	11.598ab	12.878 b	12.753a	2.856 a	3.200b	0.00041b	0.00318b	1.395a	8.719 a	0.6722 a	0.6016 a

*1=percentage germination (%), 2=Leave area (cm^2), 3=plant height (cm), 4=plant fresh weight (gm), 5=plant dry weight (gm), 6=leaves number/plant,7=chlorophyll a, 8= chlorophyll b, 9= N percentage in leave (%), 10= Protein percentage (%), 11=P percentage (%), 12=K percentage (%), at level 5%

3.4. The effect of the interaction between the amino acid and exposure periods to UV-C rays

Table 4 shows the effect of the interaction between the concentrations of the amino acid and the exposure periods to UV-C rays on the traits of the plant. It appears from it that the interaction between the concentrations of the amino acid and the exposure periods to the rays significantly affected the survival rate of the plant, where the interaction treatment between the concentration of 2 ml / liter of the amino acid with an exposure period of 15 minutes to the rays gave the lowest survival rate in that, which reached 86.67.

The table (4) also indicates the existence of significant differences for the interaction between the periods of the rays and the concentrations of the amino acids. It appears from the table that the exposure to periods of UV-C rays did not kill the plants, i.e., the plant was resistant to UV-C rays up to 60 minutes, i.e., a full hour. And that this feature can be exploited in the cultivation of the plant in hot areas, but this does not prevent the occurrence of damage to ultraviolet rays on the plant, where the exposure periods 15,60 recorded the lowest survival rate compared to the control, while spraying the plants with amino acids reduced the heat stress, where the interaction between the exposure periods 15 and the concentration of amino acids 1 ml recorded a rate of 100.0, as well as the interaction between the exposure period 60 and the concentration of amino acids 1 ml, 2 ml, and this is evidence that amino acids help to reduce the damage of the rays on the plant, especially by spraying method. The interaction treatment between the concentration of 0 amino acid and exposure to a period of 0 minutes produced the highest significant value in the leaf area per plant, which reached 17.7, and differed significantly with all the interaction treatments between the amino acid and the exposure periods to the rays, while the interaction treatment between the concentration of 0 of the amino acid and exposure to a period of 15 minutes to the UV-C rays produced the lowest significant number in that, which reached 6.18. As the table (4) records significant interactions, the leaf area decreased after exposure to different periods of UV-C rays compared to untreated seedlings, and the lowest area was in the exposure period 15 and the concentration 0. As the same table records a significant decrease in plant height (cm) and the lowest plant length resulted from the interaction treatment between the concentration of 0 ml / liter of the amino acid and exposure to a period of 15 minutes to the rays, which reached 8.93 cm. The interaction treatment between the concentration of 2 ml / liter of the amino acid with an exposure period of 15 minutes to the UV-C rays produced the highest plant length, which reached 25.23 cm, and differed significantly with the rest of the interaction treatments. As for the fresh and dry weight of the green growth, it may appear from the same table that the highest value in that resulted from the interaction between the concentration of 0 amino acid and without exposure to the rays, the lowest significant value in that reached 15.89 g for the fresh weight, as we note in the table (4) significant changes in the fresh weight of the plant, where the fresh and dry weight of the plant decreased after exposure to different periods of UV-C rays compared to the control, and the least decrease was at the treatment 15 and the concentration 0 for the fresh and dry weight, and the highest value for the dry weight resulted from the interaction between the concentration of 2 ml / liter of the amino acid and exposure to a period of 30 minutes to the UV-C rays, which reached 3.65 g, and these differed with some interaction treatments of the studied factors. The interaction treatment between the concentration of 0 ml / liter of the amino acid and no exposure to the rays produced the highest number of leaves per plant, and these differed significantly with the rest of the studied interaction treatments, and the lowest number resulted from the interaction between the concentration of 0 ml / liter of the amino acid and exposure to a period of 15 minutes to the rays.

Table (4). The interaction between the concentration of amino acid and UV-C on traits of strawberries during the growing season 2022*

Amino acid (ml.L-1)	UV-C (min.)	Mean square											
		X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12
0%	0	100.00a	17.71a	23.37ab	15.89 a	3.06 ab	5.167 a	0.0008 a	0.0020 b	1.207 ab	7.542 ab	0.753 a	0.653 a
	15	93.33ab	6.18e	8,93 b	5.37 d	1.133c	2.20 e	0.0007 a	0.0117 ab	1.010 b	6.125 b	0.637 ab	0.560 a
	30	100.00a	8.31c-e	10.00 b	11.03 bc	3.18ab	3.067b-d	0.0032 a	0.0188 a	1.303 ab	8.146 ab	0.630 ab	0.503 a
	60	93.33ab	10.02c-e	11.10 b	9.37 cd	2.40a-c	2.667c-e	0.0005 a	0.0024b	1.500 a	9.375 a	0.643 ab	0.557 a
0.012%	0	100.00a	9.15c-e	11.63 b	8.72 cd	1.967bc	2.80 c-e	0.0858 a	0.0034 b	1.300 ab	8.125 ab	0.613 ab	0.593 a
	15	100.00a	8.68c-d	11.70 b	9.18cd	2.713ab	3.33 bc	0.0009 a	0.0026 b	1.400 ab	8.750 ab	0.56 b	0.593 a
	30	93.33ab	10.19b-d	9.10 b	9.95 c	1.99bc	3.20b-d	0.0004 a	0.0026 b	1.467 ab	9.167 a	0.613 b	0.600 a
	60	100.00a	13.25b	14.57 b	14.47 ab	3.093ab	3.60b	0.0005 a	0.0051 b	1.370 ab	8.563 ab	0.597 b	0.603 a
0.024%	0	100.00a	10.79b-d	12.43 b	12.15a-c	3.12ab	3.267b-d	0.0006 a	0.0010 b	1.400 ab	8.75 ab	0.617 ab	0.607 a
	15	86.67b	7.39de	25.23 a	9.19cd	2.247a-c	2.60 de	0.0010 a	0.0027b	1.400 ab	8.77 ab	0.580 ab	0.587 a
	30	100.00a	11.82bc	14.07	14.63ab	3.65a	3.60 b	0.0006 a	0.0015 b	1.270 ab	7.938 ab	0.603 b	0.577 a
	60	100.00a	11.52bc	12.97 b	14.41ab	3.10ab	3.33bc	0.0003 a	0.0021 b	1.315 ab	8.219 ab	0.777 a	0.645 a

*1=percentage germination (%), 2=Leave area (cm^2), 3=plant height (cm), 4=plant fresh weight (gm), 5=plant dry weight (gm), 6=leaves number/plant, 7=chlorophyll a, 8= chlorophyll b, 9= N percentage in leave (%), 10= Protein percentage (%), 11=P percentage (%), 12=K percentage (%), at level 5%.

4. Discussion

4.1. The effect of amino acids

The increase in the length of the plant after treatment with amino acids may be due to the role of amino acids in building types of proteins, enzymes, and hormones necessary for plant growth. The addition of different levels of amino acids to the tomato plant, such as proline, tyrosine, and arginine, with irrigation water or sprayed on the green mass individually or mixed, produced the highest values in the traits of green growth **(Faraj and Shaker, 2011).** As **Al-Zubaidi *et al.*, 2016)**, reached in their study of the pepper plant, Flavio variety, when treated with concentrations of amino acids mg/l (0,400,800), to a significant increase in plant height, dry weight of the green mass, and total chlorophyll content in the leaves. As **Serna *et al.*, 2012**, confirmed that the green growth in the pepper plant improved when sprayed with a mixture of amino acids, which also led to an increase in the efficiency of photosynthesis, and an increase in the efficiency of antioxidants. The increase in the dry weight of the plant may be due to the increase in the amount of nitrogen and protein, as amino acids are ready units for the manufacture of protein and nucleotides **(Kasouha *et al.*, 2014)**. As for the increase in the fresh weight of the plant, it may be due to the role of amino acids in facing drought stress, as, mentioned that spraying amino acids such as salicylic on the growth and yield of wheat reduced the negative effects of water deficit on wheat. The increase in the element of nitrogen, protein, and phosphorus may be due to the fact that mixing amino acids has led to improving the traits of green growth of the plant, and thus increasing the carbohydrates manufactured in the process of photosynthesis, and thus synthesizing the enzyme Nitrate reductase to reduce nitrates and represent them, which leads to an increase in the accumulation of nitrogen and increased absorption of phosphorus and potassium and transfer it to the leaves **(Ghalebl *et al.*, 2016).**

4.2. The effect of exposure periods to UV-C rays

The decrease in the survival rate of strawberry seedlings, plant length, number of leaves, and leaf area after exposure to UV-C rays is due to oxidative stress and the formation of free radicals that affect all vital activities in the cell, which is reflected in morphological, physiological, and anatomical changes, in addition to genetic changes, as shown in Diagram number (1). The plant's response to the rays varies from one plant to another and from one stage to another **(Urban *et al.*, 2016)**.

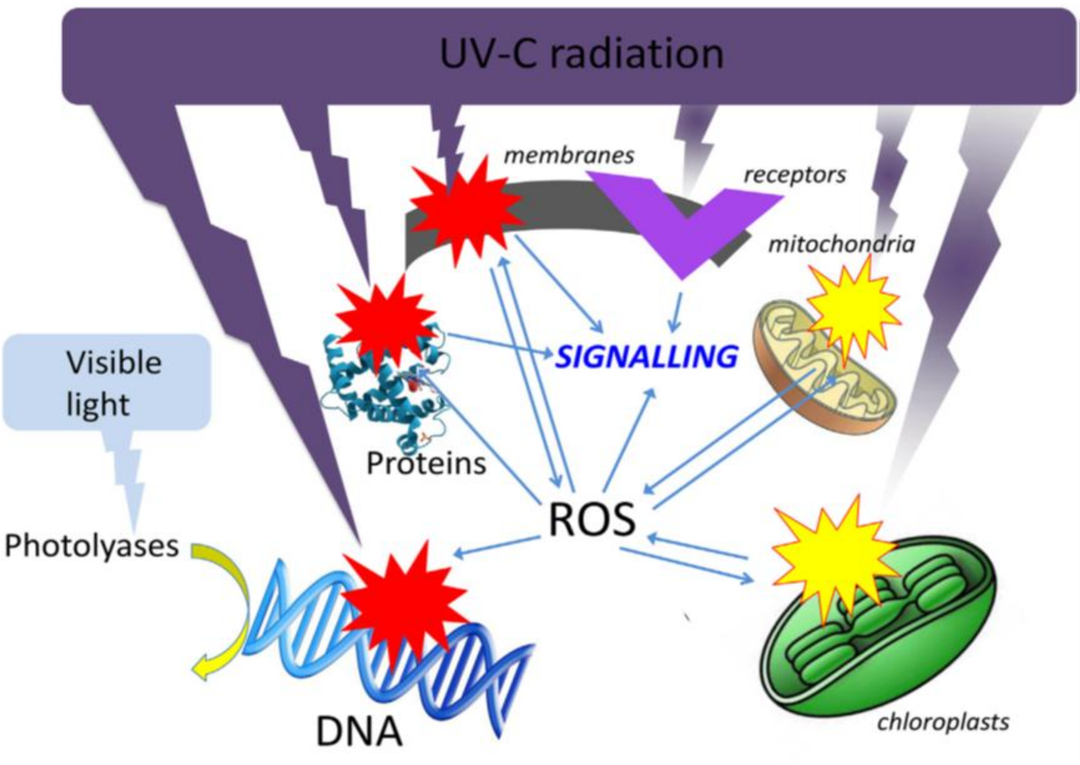

Diagram number (1) illustrates exposure to UV-C rays is due to oxidative stress and the formation of free radicals that affect all vital activities in the cell, which is reflected in morphological, physiological, and anatomical changes, in addition to genetic changes **(Urban *et al.*, 2016)**.

The decrease in the fresh and dry weight of strawberry seedlings is also due to the changes caused by the rays in the plant's biomass. **Najeeb *et al.*, 2011** confirmed in their experiment that exposing the aquatic plant Jencus effuses to three levels of UV-C rays (15, 30, 45) caused changes in the weight and mass of the aforementioned plant. **Hammok, 2019** also reached a decrease in the weight of corn seedlings after exposure to different levels of UV-C rays. Table 3 also records significant changes in the amount of chlorophyll b, where the amount of chlorophyll b decreased when exposed to a period of 30 compared to the control and the rest of the treatments. The decrease in the amount of chlorophyll is due to the role of free radicals in oxidizing fats and forming lipid peroxide in the membrane of green plastids, which affects the enzyme protochlorophyllid oxidoreductase, and thus leads to a decrease in the rate of chlorophyll accumulation **(Rai and Agrawal, 2017)**.

4.3. The effect of the interaction between the amino acid and exposure periods to UV-C rays

The interaction between the amino acid and ultraviolet rays may be due to the amino acid playing a protective or mitigating role for the harmful effects of ultraviolet rays on plants. Previous studies have shown that the amino acid reduces DNA damage, increases antioxidants, and improves the water and gas balance in plants exposed to ultraviolet rays.

Serna *et al.* (2012) mentioned that the green growth in the pepper plant improved when sprayed with a mixture of amino acids, which also led to an increase in the efficiency of photosynthesis and an increase in the efficiency of antioxidants. Many researchers have confirmed the role of amino acids in facing all forms of stress **(Faraj and Shaker, 2011; Mohamed and Khalil, 1992; Azimi *et al.*, 2013 and Darwish, 2019)**.

This is due to the effect of UV-C rays on the morphological traits of the plant and the formation of free radicals that affect all activities in the plant **(Urban *et al.*, 2016; Hammok, 2019; Hammok and Saed, 2021; Hammok and Esho, 2022)**. The decrease in plant length may be due to the effect of the rays on hormones and growth enzymes. The researcher **Najeeb *et al*, 2011** confirmed the occurrence of changes in plant growth and its biomass after exposure to different levels of UV-C rays, which are 15, 30, 45, and the reason may be due to the role of amino acids in preparing the plant with nucleotide units, vitamins, and growth hormones **(Abdul Hafiz, 2006; Amino, 2011)**.

The decrease in fresh and dry weight after exposure to UV-C rays agrees with the researchers **(Begum *et al*, 2021)** where they also recorded a decrease in fresh and dry weight after exposure to different periods of UV-C rays, which are (0,30,60,120) where the reason for the decrease in dry and fresh weight is due to the effect of the photosynthesis process and thus a lack of accumulation of biomass and this is evidence that the application of amino acids has improved or reduced the effect of the rays on the fresh and dry weight. The decrease in the number of leaves may be due to the destruction of plastids due to oxidative stress and the cessation of the photosynthesis process and thus yellowing and falling of the leaves, especially since the rays cause many physiological, morphological, and genetic changes **(Hammok and Esho, 2022; Begum *et al*, 2021)**. No significant effects of the interaction between the studied factors on the content of chlorophyll a in the plant were shown, while the interaction treatment between the concentration of 0 ml / liter of the amino acid and exposure to a period of 30 minutes produced the highest significant value in the content of chlorophyll b in the leaf and differed significantly with the rest of the interaction treatments. The increase in the amount of chlorophyll b at the exposure period of 30 agrees with the researchers **Begum *et al.*, 2021** where they reached in their research an increase in the amount of chlorophyll at the same exposure period of 30 and the reason for the increase depends on the exposure period and that chlorophyll a is more sensitive than chlorophyll b as the difference in the amount of chlorophyll may be due to the difference in the synthetic pathway of chlorophyll a and b. As for the percentage of the nitrogen element in the leaf, the interaction treatment between the concentration of 0 ml / liter of the amino acid and exposure to UV-C rays and for a period of 60 minutes produced the highest significant content, which reached 1.5 and differed significantly with the rest of the interaction treatments of the studied factors on this trait. The percentage of protein coincided with its effect by the studied factors with the percentage of nitrogen. The increase in the amount of nitrogen after exposure to UV-C rays and for a period of 60 minutes may be due to the effect of nitrogen-fixing bacteria and thus increase the plant's absorption of nitrogen from the soil and accumulate it in the plant. As for the percentage of the phosphorus element, the interaction treatment between the concentration of 2 ml / liter of the amino acid and exposure to a period of 60 minutes produced the highest significant percentage, which reached 0.777 and the lowest percentage resulted from the interaction treatment between the concentration of 1 ml / liter of the amino acid and exposure to a period of 15 minutes to the rays, which reached 0.56. The increase in the phosphorus element is evidence that the amino acids have preserved the mineral content of the plant, including the phosphorus element P, and as we mentioned earlier, the increase in the carbohydrates manufactured in the photosynthesis process and the synthesis of the enzyme Nitrate reductase to reduce nitrates and represent them, which leads to an increase in the accumulation of nitrogen and increased absorption of phosphorus and potassium and transfer it to the leaves **(Ghalebl *et al.*, 2016)** As for the percentage of the potassium element, it was not significantly affected by the interaction treatments between the studied factors.

5. Conclusions

We conclude from our research that the amino acids had a significant impact on the majority of studied traits at the level of probability 0.5%, amino acids have contributed to protecting the Strawberry plant against oxidative stress resulting from ultraviolet radiation. The period time had a significant effect on some of traits. The detrimental effect of the UV-C rays on the Strawberry plant in most of the studied traits, but the radiation did not cause the death of the Strawberry plant.

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دور الأحماض الامينية في مواجهة الإجهاد التأكسدي الناتج من تعرض شتلات الفراولة للأشعة فوق البنفسجية UV-C

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الملخص العربي

يدخل العالم حاليا في تحديات لمواجهة التغير المناخي وايجاد الوسائل البديلة في مواجهة الإجهاد التأكسدي الناتج عنه. تهدف الدراسة الى الكشف عن دور الأحماض الامينية في مواجهة الإجهاد التأكسدي الناتج من تعرض شتلات الفراولة للأشعة فوق البنفسجية uv-c. تضمنت التجربة عاملين الأول هو تراكيز الأحماض الأمينية وتشمل (v/v) (% ,0% 0.024 ,0.012%) أما العامل الثاني فيشمل فترات التعرض لأشعة uv-c وهي دقيقة/ساعة (60, 30 , 0,15) تم رش شتلات الشليك بالتراكيز أعلاه ثم تعريضها للفترات الزمنية المختلفة من أشعة uv-c ومن ثم نقل شتلات الشليك الى الحقل لمتابعة النمو وأخذ القياسات المطلوبة.

توصلت النتائج الى أن الأحماض الامينية قد أثرت بصورة معنوية في معظم الصفات المدروسة عند مستوى احتمال 5% ماعدا صفة نسبة النجاة والمساحة الورقية للنبات (سم) وعدد الأوراق وكذلك النسبة المئوية لعنصر البوتاسيوم. أما فترة التعرض لأشعة uv-c فقد أثرت معنويا على جميع الصفات باستثناء صفة نسبة النتروجين والبوتاسيوم في أوراق نبات الشليك. كما كانت معاملات التداخل بين الأحماض الامينية وفترات التعرض لأشعة uv-c معنوية في جميع الصفات المدروسة باستثناء صفة محتوى الكلوروفيل ومحتوى البوتاسيوم في الأوراق. نستنتج من بحثنا أن الأحماض الأمينية قد ساهمت في حماية نبات الشليك ضد الاجهاد التأكسدي الناتج عن الأشعة فوق البنفسجية وأن الأشعة لم تسبب موت نبات الشليك حيث أبدى نبات الشليك مقاومة ضد أشعة uv-c لحد ساعة كاملة. لذا نوصي باستخدام الأحماض الأمينية في مواجهة الإجهاد التأكسدي.