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Effect of the ergostim and amino acids on vegetative growth characteristics and mineral content of hot pepper (Capsicum annuum L.)

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Abstract

The experiment was carried out in one of the unheated greenhouses at the research station of the College of Agriculture and Marshes / University of Thi Qar, Al-Mustafawiya during the season 2021-2022. To study the effect of spraying with Ergostim and amino acids on the vegetative growth characteristics and the mineral content of the hot pepper under protected cultivation, and the cultivation of the hybrid cultivar Barbarian, the experiment was carried out using a randomized complete block design and the experiment included two factor and three replications consisting of four concentrations of Ergostim (0 and 1, 2, and 3) ml L^{-1} and three concentrations of amino acids (0, 2, and 4) ml L^{-1} by using complete randomized block design with three replicates. The averages of the treatments were compared according to the Least Significant Differences (LSD) test at the probability level of 0.05. The results showed that spraying of the Ergostim nutrient solution on the leaves had a significant effect on increasing each of (plant height, leaf area, number of branches, and the percentage of nitrogen, phosphorus and potassium in the leaves) at a concentration of (3 ml L^{-1}), as rates were recorded 100.90 cm $plant^{-1}$,133.01 dm^2 $plant^{-1}$, 11.24 branch $plant^{-1}$, 12.99%, 2.32%, 1.08%, respectively. As for the amino acids, the concentration (4 ml L^{-1}) achieved the highest levels in the above-mentioned traits. It reached 100.74 cm $Plant^{-1}$,108.63 cm ^{2} $Plant^{-1}$,10.26 cm branch plant $^{-1}$, 12.93%, 2.28%, 1.03%, respectively.

Keywords: Hot pepper, ergostim, amino acids, vegetative growth, mineral content. The research is extracted from the first researcher's message.

I. INTRODUCTION

The hot pepper (Capsicum annuum L.), which belongs to the Solanaceae family, is considered one of the important food and medicinal crops as it is one of the types of spices, which is used as a basic ingredient in a wide variety of foods all over the world, and is also used as a coloring and flavoring agent and adds flavor and taste for unappetizing foods. The fruits and seeds are the medicinal part used, whether fresh or ground, alone or with other flavoring agents, especially in pickles (Ravishankar et al., 2003). The nutritional value of hot pepper is high as it is an excellent source of vitamins A, B, C and E in addition to mineral elements such as Manganese, potassium and molybdenum, as well as chili peppers contain seven times more vitamin C compared to oranges. It also contains beta-carotenes, which, in addition to vitamins A and C, are powerful antioxidants that destroy free radicals (Simmone et al., 199).

The therapeutic properties of the hot pepper plant are attributed to a group of alkaloids known as Capsaicinoids (Ochoa-Alejo and Ramirez-Malagon, 2001). The reason for the sharpness of hot peppers is due to the alkaloid Capsaicin. Several studies showed that chili pepper extracts have anti-cancer or anti-mutagenic effects. It was found that the carotenoids present in chili pepper extracts have synergistic anti-mutagenic and anti-tumor activity (De Mejia et al., 1998 and Maoka et al., 2001).

Ergostim is one of the vital stimulants as it contains N-acetil-tiazolidin-4-carboxlic acid (AATC) and (4-tiazolidin carboxlic acid (TCA), which are molecules of proline and cysteine, which are molecules directly involved in cell division and limiting Stress, and this acid enters the cell wall, and once it is inside the cell, it turns into theoproline, which provides proline molecules inside the cell, and thus this amino acid works inside the cell and performs its multiple roles in it.This acid also provides cysteine molecules, which is an amino acid that is involved in a large number of metabolic processes of the plant, providing it with protection against environmental stresses and improving cell division in the plant (Tarantino et al., 2017).

Amino acids are considered the main initiators in the biological construction of proteins (Rai et al., 2002), which are necessary to stimulate the growth and construction of cells. There are many hypotheses that explain the role of amino acids in plant growth. The available evidence indicated that many alternative pathways for building indole acetic acid (IAA))

in plants, starting with amino acids. Amino acids are organic molecules that contain nitrogen, carbon, and hydrogen, and have a side chain in their structure, which is a characteristic of different amino acids (Buchanan et al., 2000). Amino acids are important components of antioxidant systems in plants (Renneberg and Herschbach, 2014).Ibrahim (2014) indicated that spraying eggplant plants with proline had a significant effect on the

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percentage of nitrogen, phosphorus, and potassium at rates of (1.73, 0.321, and 3.00)%, respectively, at a concentration of (200 mg L-1), as well as an increase in the content of proline and chlorophyll.

Jerry and Jarrah (2015) explained in their study on tomato plants under protected conditions that adding arginine to a spray at a concentration of (150 mg L^{-1}) had a significant effect by increasing the percentages of nitrogen and potassium at rates of (5.637 and 3.783)%, respectively, while spraying achieved Arginine, with concentrations of (75 and 150) mg L^{-1}, had the highest levels of phosphorus in the leaves, at rates of (0.375 and 0.359)%, respectively, and an increase in the percentage of each node at a rate of (73.54%), and the number of fruits at rates (58.38 and 53.46)%, respectively, and early yield. of plants by (11.21%) and kidneys by (13.12%) compared to the control treatment.Majed and Al-Hassani (2019) indicated that adding arginine to pepper plants at different concentrations (0, 75 and 150) mg L^{-1} gave a significant increase in plant height and leaf area, which amounted to (130.38 cm and 334.0 dm^2 plant ^{1}) respectively at the concentration (150 mg L^{-1}), compared with the control treatment, which amounted to (112.25 cm and 288.2 dm^2 plant ^{1}), respectively.Al-Zayadi (2021) found, when studying the effect of glutamic acid (an amino acid) at concentrations (0, 75, and 150) mg L^{-1} on chili pepper plants, that glutamic acid had a significant effect on all the studied traits, as the plants that were sprayed with a concentration of (150 mg.L) $^{-1}$) It excelled significantly in plant height, number of leaves, number of main branches, number of fruits, and fruit yield, and recorded the highest values, which amounted to (53.12 cm, 136.4 leaves. $Plant^{-1}$, 4.22 branches, $Plant^{-1}$, 11.4 fruits, $Plant^{-1}$, and 0.316 kg. $Plant^{-1}$), respectively, compared to the control treatment, which recorded the lowest values.

II. MATERIALSAND METHODS OF WORK

The study was conducted in Thi-Qar Governorate - Nasiriyah City - Al-Mustafawiya region, for the agricultural season 2020/2021 in one of the unheated plastic houses belonging to the fields of the Department of Horticulture and Landscape Engineering - College of Agriculture and Marshes / Thi-Qar University in sandy mixed soil for the purpose of studying the effect of Ergostim and amino acids on traits. The physical and chemical plant of hot pepper.

The experiment included two factors：

The first factor: Ergostim nutrient solution with concentrations :

1- Control treatment (spraying with distilled water only)

2- Treatment with Concentration(1ml L^{-1})

3- Treatment with Concentration (2 ml L^{-1})

4- Treatment with Concentration(3ml L^{-1})

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The second factor: amino acids in concentrations:

1- Control treatment (spraying with distilled water only)

2- Treatment with Concentration (2 ml L^{1-})

3- Treatment with Concentration (4 ml L^{-1})

Each concentration was prepared separately and drops of the dispersant material (Tween20) were added to it to reduce the surface tension. After shaking, stirring and homogenizing well, the plant was sprayed until completely wet and in the early morning using a 16-liter sprinkler.

The process of analyzing the soil of the plastic house and the water used for irrigation was carried out before planting, and the results of the analysis were according to what is mentioned in Tables (1 and 2).

Table (1) Some chemical and physical properties of the soil of the plastic house.

	Analysis type	The value	Unit
1	EC	1.2	ds/m
2	PH	7.43	/
3	CEC	19.4	m mole
4	OM	7.6	m mole
5	$CaCo_3$	203.4	m mole.kg^{-1}
6	Ca^+	4.3	m mole.kg^{-1}
7	Mg^+	2.8	m mole.kg^{-1}
8	Na^+	7.4	m mole.kg^{-1}
9	K^+	0.8	m mole.kg^{-1}
10	Cl^-	2.7	m mole.kg^{-1}
11	SO_4	6.4	m mole.kg^{-1}
12	CO_3	/	m mole.kg^{-1}
13	HCO_3	0.98	m mole.kg^{-1}
14	N	12.8	mg/kg m
15	P	6.3	mg/kg m
16	K	39.8	mg/kg m
17	Sand	22.9	%

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18	Silt	45	%
19	Clay	32.1	%

Table (2) Chemical and physical analysis of irrigation water in the greenhouse.

	Analysis type	**The value**	**Unit**
1	PH	7.28	/
2	EC	1.4	mg/L
3	TDS	912	mg/L
4	T.H	201	mg/L
5	HCO_3	12.3	mg/L
6	CO_3	0	mg/L
7	Ca^{+2}	37.4	mg/L
8	Mg^{+2}	12.4	mg/L
9	Na^{+}	103	mg/L
10	K^{+}	5.2	mg/L
11	NO_3	0.11	mg/L
12	P	0.12	mg/L
13	CL^{-}	200	mg/L
14	SO_4	310	mg/L
15	TSS	740	mg/L

Studied traits:

Plant height (cm plant^{-1}) .

The height of the plants was measured using a metric tape, starting from the point of contact of the stem with the soil surface to the growing top of the plant, according to its rate.

Leave area (dm^{2} plants $^{-1}$).

The leaf area was calculated at the end of the harvest season for six plants, and it was calculated on the basis of the dry weight of the leaves, as 30 circular pieces were cut from the leaves of the selected plants with known areas

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(2 cm^2 pieces), then they were dried at a temperature of 70 C for a period of 48 hours, then weighed, as were all The leaves of the selected plants were dried. The leaves of each plant were dried separately from the leaves of the other plants at a temperature of 70 °C for a period of 48 hours, then weighed according to the average leaf area ($dm^2 plant^{-1}$), according to the equation mentioned by Ahmed (1984), as follows:

$$\text{Leave area}(dm^2) = \frac{\text{dry weight of leave(gm)} \times \text{Square cut area}(cm^2)}{\text{dry weight of Square cut (gm)}}$$

Number of branches (branch $plant^{-1}$).

The number of branches was measured for six randomly selected plants from each experimental unit by calculating the number of lateral branches on the main stem of each plant and according to their average.

Estimation of nutrients (macroelements) in leaves .

Nutrients (nitrogen, phosphorous and potassium) were estimated in leaves and fruits by taking the fourth leaf from the growing apex of the marked plants and for each experimental unit. The leaves and fruits were washed to remove dust and dried in an electric oven at 65 °C for 72 hours until weight stability (Al-Sahhaf, 1989), then they were ground and 0.2 was taken. grams of the crushed sample. The samples were digested by adding 4 ml of concentrated sulfuric acid 95% and 2 ml of concentrated perchloric acid according to what was mentioned by (Jones and Steyn, 1973). The elements mentioned were estimated as follows:

1- The percentage of nitrogen in the leaves(%).

The Keldahl method was used to estimate the percentage of nitrogen in the samples, based on the method mentioned by (van Dijk and Houba, 2000).

2- The percentage of phosphorus in the leaves(%).

The phosphorus content of the leaves was calculated according to the method (Page, 1982).

3- The percentage of potassium in the leaves(%).

Potassium was estimated in plant samples according to the method of (Haynes, 1980) .

III. RESULTS AND DISCUSSION

Plant height (cm plant^{-1}).

It is noted from the results in Table (3) that spraying the plants with Ergostim concentrations had a significant effect on increasing the rates of plant height, as the concentration treatment (3 ml L^{-1}) achieved the highest rate of (100.90 cm), which did not differ significantly with the two concentrations treatments (1 and 2) ml L^{-1}, compared to the control treatment, which recorded the lowest rate (95.32 cm).

Table (3) Effect of Ergostim and amino acids on the height of chili pepper plant (cm^{-1} plant).

Average effect ergostim	Concentration amino acid (mlL^{-1})			Concentration ergostim(mlL^{-1})
	4	**2**	**0**	
95.32	**100.54**	**100.41**	**85.00**	**0**
100.51	**100.63**	**100.55**	**100.35**	**1**
100.76	**100.82**	**100.76**	**100.71**	**2**
100.90	**100.97**	**100.92**	**100.81**	**3**
	100.74	**100.66**	**96.72**	Average effect amino acid
	Interference **2.433** =	=Amino acid **1.217**	= Ergostim **1.405**	**R.L.S.D(0.05)**

As for the effect of spraying with concentrations of amino acids, it was significant in the characteristic of plant height, and the concentration treatment (4 ml L^{-1}) gave the highest rate of (100.74 cm), which did not differ significantly with the treatment of concentration (2 ml L^{-1}), which recorded a rate of (100.66 cm), and compared with the control treatment, which recorded the lowest rate with a significant difference of (96.72 cm).

As for the interaction coefficients between the concentrations of Ergostim and amino acids, some of them were significant in its effect on the characteristic of plant height. cm), while the control treatment (Ergostim at a

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concentration of (0 ml L^{-1}) and amino acids at a concentration of (0 ml L^{-1})) recorded the lowest rate of (85.00 cm).

Leave area (dm ^{2} plant $^{-1}$)

The results of table (4) showed the significant effect of Ergostim by increasing the leaf area with an increase in the concentration of Ergostim, as the concentration (3 ml L^{-1}) gave the highest rate for this trait amounted to (133.01 dm^2 $plant^{-1}$) compared with the control treatment, which recorded the lowest rate of (75.43 dm2 $plant^{-1}$).

Table (4) Effect of Ergostim and amino acids on the leaf area of chili pepper (dm^2 $plant^{-1}$).

Average effect ergostim	Concentration amino acid (mlL^{-1})			Concentration ergostim(mlL^{-1})
	4	**2**	**0**	
45.88	**58.33**	**47.95**	**31.38**	**0**
82.44	**95.53**	**81.30**	**70.49**	**1**
109.45	**129.73**	**110.99**	**87.64**	**2**
133.01	**150.92**	**135.88**	**112.21**	**3**
	108.63	**94.03**	**75.43**	Average effect amino acid
	Interference = **7.471**	= Amino acid **3.736**	= Ergostim **4.314**	**R.L.S.D(0.05)**

As for the effect of spraying with concentrations of amino acids, it was significant by increasing the leaf area with increasing the concentration of amino acids. The treatment with a concentration of (4 ml L^{-1}) achieved the highest rate of (108.63 dm^2 $plant^{-1}$) compared to the control treatment, which recorded the lowest rate of (75.43 dm^2 $plant^{-1}$).

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As for the effect of interactions between the concentrations of Ergostim and amino acids, some of them were significant by increasing the leaf area, and the interaction treatment between Ergostim (3 ml L^{-1}) and amino acids at a concentration of (4 ml L^{-1}) gave the highest rate of (150.92 dm^2 $plant^{-1}$)., compared with the control treatment (Ergostim at a concentration of (0 ml L^{-1}) and amino acids at a concentration of (0 ml L^{-1}), which recorded the lowest rate of (31.38 dm^2 $plant^{-1}$).

Number of branches (branch plant $^{-1}$).

It was noted from the results of Table (5) that spraying Ergostim concentrations caused a significant increase in the number of branches in the plant with an increase in Ergostim concentration, as the concentration treatment (3 ml L^{-1}) achieved the highest rate of (11.24 branches of $Plant^{-1}$), compared to the treatment of Ergostim. The control that recorded the lowest rate was (7.32 $plant^{-1}$ branches).

Table (5) Effect of Ergostim and amino acids on the number of branches of the hot pepper plant (branch plant $^{-1}$)

Average effect ergostim	Concentration amino acid (mlL^{-1})			Concentration ergostim(mlL^{-1})
	4	**2**	**0**	
7.32	**9.37**	**7.93**	**4.67**	**0**
9.18	**9.87**	**7.93**	**9.73**	**1**
9.99	**9.97**	**9.80**	**10.20**	**2**
11.24	**11.83**	**11.67**	**10.23**	**3**
	10.26	**9.33**	**8.71**	Average effect amino acid
	Interference = **1.418**	=Amino acid **0.709**	= Ergostim **0.819**	**R.L.S.D(0.05)**

As for the effect of spraying amino acids, it was significant in increasing the number of branches in the plant with an increase in the concentration of amino acids. 8.71 branch plant $^{-1}$).

The effect of the interaction coefficients between the factors of the study, some of which were significant in increasing the number of branches in the plant, as the interaction treatment between (Ergostim at a concentration

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of (3 ml L^{-1}) and amino acids at a concentration of (4 ml L^{-1}) achieved the highest rate of (11.83 plant branches^{-1}), which did not differ significantly with the interaction treatment between (Ergostim (3 ml L^{-1}) and amino acids at a concentration of (2 ml L^{-1}), which recorded an average of (11.67 branches plant $^{-1}$) and compared with the control treatment, which recorded the lowest rate It reached (4.67 branches plant^{-1}).

The percentage of nitrogen (%) in the leaves

It is noted from Table (6) that spraying with Ergostim concentrations caused a significant increase in the percentage of nitrogen in the leaves with an increase in Ergostim concentration, as the concentration treatment (3 ml L^{-1}) achieved the highest rate of (12.99%) compared to the control treatment, which recorded the lowest. The rate reached (12.21%).

Table (6) Effect of Ergostim and amino acids on the percentage of nitrogen in the leaves of the hot pepper plant(%).

Average effect ergostim	Concentration amino acid (mL^{-1})			Concentration ergostim(mlL^{-1})
	4	**2**	**0**	
12.21	**12.32**	**12.20**	**12.12**	**0**
12.54	**12.83**	**12.55**	**12.26**	**1**
12.66	**12.97**	**12.66**	**12.35**	**2**
12.99	**13.61**	**12.82**	**12.55**	**3**
	12.93	**12.56**	**12.32**	Average effect amino acid
	Interference = **0.078**	=Amino acid **0.039**	= Ergostim **0.045**	**R.L.S.D(0.05)**

Spraying the leaves with concentrations of amino acids caused a significant increase in the percentage of nitrogen in the leaves with an increase in the concentration of amino acids, as the concentration treatment (4 ml L^{-1})

achieved the highest rate of (12.93%) compared to the control treatment, which recorded the lowest rate of (12.32%).

As for the effect of the interaction treatments between the two factors of the study, some of them were significant in increasing the percentage of nitrogen in the leaves, and the interaction treatment between (Ergostim at a concentration of (3 ml L^{-1}) and amino acids at a concentration of (4 ml L^{-1})) achieved the highest rate of (13.61%) Compared to the control treatment, which recorded the lowest rate (12.12%).

Percentage of phosphorus (%) in the leaves.

The results showed in Table (7) that spraying Ergostim concentrations had a significant effect on increasing the percentage of phosphorus in the leaves with increasing its concentration, as the concentration treatment (3 ml L^{-1}) achieved the highest rate of (2.32%) compared to the control treatment, which recorded the lowest rate. It reached (1.48%).

Table (7) Effect of Ergostim and amino acids on the percentage of phosphorus in the leaves of the hot pepper plant(%).

Average effect ergostim	Concentration amino acid (mlL^{-1})			Concentration ergostim(mlL^{-1})
	4	**2**	**0**	
1.48	**1.60**	**1.47**	**1.36**	**0**
1.78	**2.05**	**1.75**	**1.55**	**1**
2.05	**2.57**	**1.91**	**1.66**	**2**
2.32	**2.90**	**2.27**	**1.79**	**3**
	2.28	**1.85**	**1.59**	Average effect amino acid
	Interference = **0.029**	=Amino acid **0.014**	= Ergostim **0.017**	**R.L.S.D(0.05)**

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The results also showed the significant effect of spraying with concentrations of amino acids by increasing the content of leaves from the percentage of phosphorus with increasing the concentration of amino acids, and the concentration treatment (4 ml L^{-1}) achieved the highest rate of (2.28%), compared with the control treatment, which recorded the lowest rate of (1.59%).

As for the effect of the interaction coefficients between the two study factors, some of them were significant by increasing the percentage of phosphorus in the leaves, as the interaction treatment between (Ergostim with a concentration of (3 ml L^{-1}) and amino acids with a concentration of (4 ml L^{-1})) achieved the highest rate of (2.90%)) compared to the control treatment, which recorded the lowest rate (1.36%).

The percentage of potassium (%) in the leaves.

The results in Table (8) indicate the significant effect of spraying with Ergostim concentrations by increasing the percentage of potassium in the leaves with an increase in Ergostim concentration, as the concentration treatment (3 ml L^{-1}) achieved the highest rate of (1.08%) compared to the control treatment, which recorded the lowest rate. It reached (0.63%).

Table (8) Effect of Ergostim and amino acids on the percentage of potassium in the leaves of the hot pepper plant (%).

Average effect ergostim	Concentration amino acid (mlL^{-1})			Concentration ergostim(mlL^{-1})
	4	**2**	**0**	
0.63	**0.75**	**0.60**	**0.55**	**0**
0.85	**0.99**	**0.87**	**0.71**	**1**
1.00	**1.15**	**1.06**	**0.80**	**2**
1.08	**1.24**	**1.11**	**0.90**	**3**
	1.03	**0.91**	**0.74**	Average effect amino acid

	Interference = **0.01700**	=Amino acid **0.00850**	= Ergostim **0.00981**	**R.L.S.D(0.05)**

As for the effect of spraying with concentrations of amino acids, it was significant in its effect by increasing the percentage of potassium in the leaves, and the concentration treatment (4 ml L^{-1}) achieved the highest rate of (1.03%), compared to the control treatment, which recorded the lowest rate of (0.74%).

As for the interaction coefficients between the two study factors, some of them had a significant effect by increasing the percentage of potassium. With the control treatment, which recorded the lowest rate (0.55%).

It is noted from the results of tables (3, 4 and 5) that spraying the leaves of the hot pepper plant with concentrations of the nutrient solution (Ergostim) caused a significant increase in each of (plant height, leaf area and number of branches). acetyl-tiazolidin-4-carboxlic acid (AATC) and 4-tiazolidin carboxlic acid (TCA)

Once these two compounds enter the cell wall and are present inside the cell, they turn into the two amino acids proline and cysteine, as proline performs many physiological functions that help the plant to grow, develop, flower and bear fruit well, including:

1-Regulating the osmotic potential within the cytoplasm and protecting the cell from high concentrations of toxic ions trapped inside the vacuole as a result of the environmental stressors that the plant is exposed to (Hare et al., 1996).

2-It maintains the activity of enzymes from the dentin when the plant is exposed to any type of environmental stress (Demir and Kocacaliskan, 2001).

3-Protecting cell organelles from highly effective oxygen species, which cause oxidative damage in many cellular compounds, including proteins and nucleic acids, which are considered among the basic components of the cell and which cause plant growth to stop if damaged (Hare et al., 1996).

4-The amino acid proline is a source of energy for ATP (adenine triphosphate) and the reducing power of NADPH by oxidizing it to Pyrroline-5-Carboxylate proline dehydrogenase located in the inner membrane of mitochondria. This enzyme is linked to the respiratory electron-transport system that accompanies the breakdown of proline. and the production of ATP (Elthon and Stewart, 1981), and the reason may be due to the fact that the organic nutrient solutions (organic fertilizers), including the Ergostim solution, play a major role in increasing nitrogen levels, as shown in the results of Table (6), since the Ergostim contains in its composition the two amino acids proline and cysteine Which are considered a source of nitrogen, and the results showed in Table (7) an increase in the content of the leaves of the element phosphorus by the effect of the nutrient solution Ergostim and amino acids, and the element of phosphorus plays a role in improving the growth of roots and then increasing their efficiency in absorption, as well as the results showed an increase in the content of leaves and fruits of the element potassium table (8), and potassium contributes effectively to building carbohydrates.

The results showed that spraying the leaves of the hot pepper plant with concentrations of amino acids caused a significant increase in each of (plant height, leafy area, and number of branches). Protein, therefore, its importance and effectiveness fall within the stages of plant growth in terms of participating in increasing the cell's ability to absorb mineral nutrients and water from the growth medium, and then increasing vegetative growth. In addition, amino acids increase the formation of proteins that contribute to the many functions of plant metabolism. It increases the rate of carbon uptake, as this leads to an increase in dry matter, which is reflected in plant growth and yield (Abu-Dahi, 1988, ALYounis, Dreccer, et al., 2000, Sharma-Natu, and Ghildiyal, 2005). It can also be attributed to the superiority of plants sprayed with amino acids. That the amino acids improved the nutrition of the plant and thus increased the concentration of nitrogen in the leaves in addition to the fact that the amino acids are a source of nitrogen and also contribute to an increase in the speed of mattation Nitrogen uptake from the leaf as well as increasing its representation and storage inside the plant (Bidwell, 1979), leading to the formation of a large and strong vegetative clump that facilitates the absorption of all nutrients by the plant, including the elements phosphorus and potassium, as in Tables (7 and 8).

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