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The Effectiveness of Applying Foliar Spray with Nano Amino Acids and Zinc in Stimulating the Chemical Content of Leaves and Fruits of Eggplant

Thanaa Salih Aziz Al-Khaqani[1], Mansoor Abed Aboohanah[2]
[1,2]Department of Horticulture and Landscape, Faculty of Agriculture, University of Kufa, Najaf, Iraq.
E-mail: [1]thanaasalihaziz@gmail.com

Abstract
The experiment was carried out in the Horticulture and Forestry Division of the Directorate of Najaf province, during 2020-2021 season to examine the effect of spraying three concentrations of Nano amino acids on eggplant (0, 1 and 2 ml.L^{-1}) and zinc (0, 75, 150 mg.L^{-1}). Results showed that the treatment of 2ml.L^{-1} of Nano amino acids was achieved significant increasing in leaves content of nitrogen, potassium, zinc and total chlorophyll, and the fruits content of carbohydrates, protein, vitamin C, Solanine and Nitrate as it amounted 2.74, 2.98%, 14.25 mg.kg^{-1} dry weight, 86.30mg.100g-1 fresh weight, 13.85mg.g^{-1}, 15.34%, 22.02mg.ml $juice^{-1}$, 1804.5micro $g.g^{-1}$ dry weight, 328.8mg.g^{-1} dry weight respectively compare to control treatment which recorded the lowest values of above traits. While, spraying eggplant with 150mg.L^{-1} concentration of zinc was significantly exceeded and recorded an increasing in leaves content of nitrogen, potassium, zinc and total chlorophyll and the fruits content of carbohydrates, protein, vitamin C, Solanine and Nitrate that amounted 2.30, 2.33% and 10.93mg.kg^{-1} dry weight, 75.44mg.$100g^{-1}$ fresh weight, 1255mg.g^{-1}, 12.78%, 20.34mg.100ml $juice^{-1}$, 1646.3 micro $g.g^{-1}$ dry weight, 298.8mg.g^{-1} dry weight in comparison with control treatment which decreased in the studied traits. The interaction between 2m.L^{-1} of Nano amino acids with 150mg.L^{-1} of zinc gave significant increasing in leaves content of nitrogen, potassium, zinc and total chlorophyll and the fruits content of carbohydrates, protein, vitamin C, Solanine and Nitrate, as it recorded 2.81, 3.12% and 16.33mg.kg^{-1} dry weight, 87.71mg.$100g^{-1}$ fresh weight, 15.00mg.g^{-1}, 15.87%, 23.45mg.100ml $juice^{-1}$, 1989.2 micro $g.g^{-1}$ dry weight, 367.9mg.g^{-1} dry weight compare to control treatment.

Key words: eggplant, Nano amino acids, zinc, chemical content, foliar spraying.

INTRODUCTION

Eggplant (*Solanum melongena* L.) is a vegetable crop belongs to Solanaceae and it is considered an important plant family economically, this family comprises more than 75 genera and 2000 plant species spread globally (Al-Muhamady 1990). It is believed that the original home of eggplant is India, and it originates from the ancient wild species that grew in central India and southeast China then from there it spread to Africa, Spain and various regions of the world (Al-Kafagy and Al-Muktar 1989). The crop is grown in most areas of Iraq in open fields, as well as in protected agriculture such as green houses and tunnels. Eggplant is an important summer vegetable crop due to the increased demand for it and the

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market absorption of all the quantities offered throughout the year, as well as its good economic return to the producers, and the total areas cultivated by eggplant in the world reached 1847787 hectares with a productivity of 55197878 tons, while, the total cultivated areas in Iraq reached 8660 hectares with a productivity of 136749 tons (FAO 2021). Fertilizers and organic materials prepared with nanotechnology are considered environmentally friendly and contribute to reducing pollution and are of great importance to promote sustainable agricultural development as this new technology enabled the exploitation of small nanomaterial particles that are carried on compost to build so-called smart fertilizers that enhance the efficiency of nutrient use and reduce environmental protection costs (Cui et al 2010). The addition of amino acids by spraying on leaves depends on the plant need and the stage of growth, it is absorbed through the stomata in leaves and the absorption process is affected by the temperature of surrounding environment (Stino et al 2010).

Zinc is a micro nutrient necessary for plant growth and the completion of his life cycle, although the plant needs very small amounts of zinc (Hague et al 2011). It is possible to give zinc element by spraying it on the vegetative growth of plant with a so-called foliar application (Abo Dahy and Al Uonis 1988), or by soil (Megan 2004). Foliar nutrients are a necessary and effective assistant with fertilizers to increase production (Kostadinov and Kosladinova 2014), also zinc has important roles including that it helps increase the activity of many enzymes especially Carboxylase, Carbonic anhydrate and Dehydrogenases (Pandy 2013). Moreover, zinc also has a role in producing pollen, lipids, nucleic acids, stabilizing DNA, regulating gene expression and multiplying cells as well as being involved in the synthesis and activation of about 300 enzymes (Hafeez et al 2013). Based on the above and the importance of this crop, the current study aimed to use Nano amino acids in foliar fertilization of eggplant and to indicate the extent of their effect on growth and yield traits as well as the zinc spray test for its role in improving plant growth.

MATERIALS AND METHODS

A factorial experiment was carried out using Randomized Complete Block Design (RCBD) in one field of the Horticulture and Forestry Division of the Directorate of Najaf province during 2020-2021 season with two factors and three replicates. The first factor is Nano amino acids and the second factor is the foliar spray of zinc as liquid zinc sulphate ($ZnSO_4.7H_2O$) with three sprayings during the season, the first spray was applied when plants have 4 mature leaves, the second spray was applied in the beginning of flowering and the third spray was applied after the second spray by two weeks. The differences between means were tested using least significant difference (L.S.D) at 0.05(AL–Rawi and Khalf 2000).

Field soil was prepared by tilling and levelling then the area was divided into three lines, 50 cm distance between each line, the line contains 9 experimental units then mineral fertilizer (Triple calcium superphosphate) was added by an average of 100kg/dunum and 60kg urea scattered on one side of line (Al-Kafagy and Al-Muktar 1989). Thoraya hybrid eggplant seeds (West Frisian – Thailand) were sawn in 1/3/2020 in cork dishes filled with an agricultural medium containing sandy soil and peat moss in a ratio of 1:2 respectively. Dishes were placed inside a wooden canopy, after that, when seedlings became 10-15cm high and contain 3-4 mature leaves which means it ready for planting, seedlings were transferred to the

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open field in 1/4/2020 on one side of the line and 50cm left between each plant (Al-Assaf 1983).

Experimental treatments

T0: Thoraya cultivar + interaction between Nano amino acid 0ml.L^{-1} + zinc 0mg.L^{-1}.
T1: Thoraya cultivar + interaction between Nano amino acid 0ml.L^{-1} + zinc 75mg.L^{-1}.
T2: Thoraya cultivar + interaction between Nano amino acid 0ml.L^{-1} + zinc 150mg.L^{-1}.
T3: Thoraya cultivar + interaction between Nano amino acid 1ml.L^{-1} + zinc 0mg.L^{-1}.
T4: Thoraya cultivar + interaction between Nano amino acid 1ml.L^{-1} + zinc 75mg.L^{-1}.
T5: Thoraya cultivar + interaction between Nano amino acid 1ml.L^{-1} + zinc 150mg.L^{-1}.
T6: Thoraya cultivar + interaction between Nano amino acid 2ml.L^{-1} + zinc 0mg.L^{-1}.
T7: Thoraya cultivar + interaction between Nano amino acid 2ml.L^{-1} + zinc 75mg.L^{-1}.
T8: Thoraya cultivar + interaction between Nano amino acid 2ml.L^{-1} + zinc 150mg.L^{-1}.

Measured traits

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

Nitrogen percentage in leaves was estimated using Kjeldahl device following Al-Sahaf (1989) method.

2- The percentage of potassium in leaves (%).

Leaves content of potassium was estimated using Flame photometer after preparing series of standard concentrations of potassium according to Al-Sahaf (1989).

3- Leaves content of zinc (mg.kg^{-1} dry weight).

Zinc content in leaves was estimated using Spectrophotometer according to Lendcy and Norfel (1978) method.

4- Leaves content of total chlorophyll (mg.$100g^{-1}$ fresh weight).

Total chlorophyll was estimated using Spectrophotometer at wavelength 645 and 663nm (Goodwin 1976).

5- Fruits content of carbohydrate (mg.g^{-1} dry weight).

UV –visible Spectrophotometer was used to measure the optical absorption of carbohydrate at 560nm wavelength (Joslyn 1970).

6- The percentage of protein in fruits (%).

The percentage of protein was estimated depending on the percentage of total nitrogen using Kjeldahl device following Al-Sahaf (1989) method.

7- Fruits content of vitamin C (mg.100mljuice^{-1}).

Fruits content of vitamin C was estimated using Spectrophotometer at 518nm wavelength according to Abass and Abass (1992).

8- Fruits content of nitrates (mg.g^{-1} dry weight).

The proportion of nitrates in eggplant fruits was estimated using Spectrophotometer at 410nm wavelength according to Cataldo et al (1975).

9- Fruits content of Solanine (micro g.g^{-1} dry weight).

Solanine was estimated by using HPLC as two dynamic phases were used to perform the first separate consisting 0.1% of chloroacetic acid and the second dynamic phase was consisted of Acetonitrile HPLC then the gradation was performed according to the total time of the two dynamic phases following (Maurya et al 2013).

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RESULTS AND DISCUSSION

Results of Table 1 showed that spraying 2ml.L^{-1} of Nano amino acids was significantly increased studied traits in leaves content of nitrogen, potassium, zinc and total chlorophyll as it amounted 2.74, 2.98%, 14.25mg.kg^{-1} dry weight, 86.30 mg.100 g^{-1} fresh weight, compare to control treatment that recorded 1.09, 1.55% and 6.55 mg.kg^{-1} dry weight, 60.48 mg.100 g^{-1} fresh weight respectively. Spraying 150 mg.L^{-1} of zinc was significantly increased the leaves content of of nitrogen, potassium, zinc and total chlorophyll, when it recorded 2.30, 233% and 10.93 mg.kg^{-1} dry weight, 75.44 mg.100g^{-1} fresh weight in comparison with control treatment which recorded decreasing in the above traits when it amounted 1.72, 2.04% and 9.78mg.kg^{-1} dry weight, 69.73 mg.100g^{-1} fresh weight respectively. The interaction between 2m.L^{-1} of Nano amino acids with 150mg.L^{-1} of zinc gave significant increasing in leaves content of nitrogen, potassium, zinc and total chlorophyll as it recorded 2.81, 3.12% and 16.33mg.kg^{-1} dry weight, 87.71mg.100g^{-1} fresh weight compare to control treatment that recorded a decreasing in studied traits amounted 0.79, 1.43%, 6.52 mg.kg^{-1} dry weight, 58.90 mg.100g^{-1} fresh weight respectively.

Table 1. The effect of Nano amino acid and zinc and their interaction on the average of leaves content of nitrogen (N), potassium(K), zinc (Zn) and total chlorophyll of eggplant.

Total chlorophyll (mg.100g^{-1} fresh weight)	Zinc (mg.kg^{-1} dry weight)	Potassium %	Nitrogen %	Treatments
58.90	6.52	1.43	0.79	T0
60.98	6.55	1.54	0.81	T1
61.57	6.59	1.68	1.68	T2
66.07	9.82	1.82	1.74	T3
68.22	9.85	2.09	2.00	T4
77.06	9.88	2.18	2.42	T5
84.22	13.02	2.86	2.63	T6
86.98	13.42	2.95	2.78	T7
87.71	16.33	3.12	2.81	T8
0.390	0.020	0.20	0.204	LSD A
60.48	6.55	1.55	1.09	The average of Nano amino acid effect
70.45	9.85	2.03	2.05	
86.30	14.25	2.98	2.74	
0.390	0.020	0.20	0.204	LSD B
69.73	9.78	2.04	1.72	The average of

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72.06	**9.94**	**2.19**	**1.86**	**zinc effect**
75.44	**10.93**	**2.33**	**2.30**	
0.676	**0.034**	**0.35**	**0.354**	**LSD AB**

Table 2 results showed that spraying 2ml.L^{-1} of Nano amino acid on vegetative part of eggplant was significantly increased the percentage of carbohydrates, protein, vitamin C, Solanine and Nitrate of eggplant fruits as it amounted 13.85mg.g^{-1}, 15.34%, 22.02mg.100 ml $juice^{-1}$, 1804.5 micro g.g^{-1} dry weight, 328.8 mg.g^{-1} dry weight compare to control treatment that recorded decreasing in studied traits amounted 9.32 mg.g^{-1}, 5.15%, 16.52 mg.100 ml $juice^{-1}$, 1301.2 micro g.g^{-1} dry weight, 231.1 mg.g^{-1} dry weight respectively. Results also showed that spraying 150mg.L^{-1} of was significantly exceeded other treatments in increasing fruits content of carbohydrates, the percentage of protein, vitamin C, Solanine and Nitrate, when it amounted 12.55mg.g^{-1}, 12.78%, 20.34mg.100 ml $juice^{-1}$, 1646.3 micro g.g^{-1} dry weight, 298.8 mg.g^{-1} dry weight compare to control treatment which recorded decreasing in the above traits to 10.68mg.g^{-1}, 8.95%, 18.30 mg.100 ml $juice^{-1}$, 1442.1 micro g.g^{-1} dry weight, 258.5 mg.g^{-1} dry weight respectively. Results also indicated significant interaction spraying 2ml.L-1 concentrations of nano amino acid and 150mg.L-1 of zinc as it increased the percentage of carbohydrates, the percentage of protein, vitamin C, Solanine and Nitrate in eggplant fruits, when it amounted 15.00mg.g^{-1}, 15.87%, 23.45mg.100 ml $juice^{-1}$, 1989.2 micro g.g^{-1} dry weight, 367.9 mg.g^{-1} dry weight compare to control treatment which recorded decreasing in the above traits to 8.55mg.g^{-1}, 3.63%, 15.27 mg.100 ml $juice^{-1}$, 1219.4 micro g.g^{-1} dry weight, 215.5 mg.g^{-1} dry weight respectively.

Table 2. The effect of Nano amino acid and zinc and their interaction on the average of fruits content of the percentage of carbohydrates, the percentage of protein, vitamin C, Solanine and Nitrate of eggplant.

Nitrate (mg.g^{-1} dry weight)	**Solanine (micro g.g^{-1} dry weight)**	**Vitamin C (mg.100.ml $juice^{-1}$)**	**Protein %**	**Carbohydrates (mg.g-1)**	**Treatments**
215.7	**1219.4**	**15.27**	**3.63**	**8.55**	**T0**
221.0	**1348.0**	**16.69**	**3.83**	**9.51**	**T1**
256.5	**1336.4**	**17.60**	**8.00**	**9.91**	**T2**
265.0	**1445.2**	**19.56**	**8.56**	**10.55**	**T3**
267.3	**1559.6**	**19.80**	**9.65**	**11.64**	**T4**
272.2	**1613.3**	**19.97**	**14.48**	**12.75**	**T5**
294.7	**1661.7**	**20.07**	**14.68**	**12.94**	**T6**
323.8	**1762.6**	**22.56**	**15.48**	**13.63**	**T7**
367.9	**1989.2**	**23.45**	**15.87**	**15.00**	**T8**

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1.74	**15.06**	**0.191**	**0.310**	**0.171**	**LSD A**
231.1	**1301.2**	**16.52**	**5.15**	**9.32**	**The average of Nano amino acid effect**
268.1	**1539.4**	**19.78**	**10.89**	**11.65**	
328.8	**1804.5**	**22.02**	**15.34**	**13.85**	
1.74	**15.06**	**0.191**	**0.310**	**0.171**	**LSD B**
258.5	**1442.1**	**18.30**	**8.95**	**10.68**	**The average of zinc effect**
270.7	**1556.7**	**19.68**	**9.65**	**11.59**	
298.8	**1646.3**	**20.34**	**12.78**	**12.55**	
3.02	**26.09**	**0.331**	**0.537**	**0.296**	**LSD AB**

It can be noticed in Table 1 that the treatment of Nano amino acid was increased chlorophyll content in leaves and this may be attributed to its role in building chlorophyll as the amino acid binds with succiny1-CoA compound to form alpha-aminolevulinic acid and then form tetrapyrrol which is make chlorophyll molecule and supply plant cells with nitrogen (Mohammed A K and Al Uonis M A 1991). These results are in agreement with Hendry and Statuart (1977) who studied barley plant and with Peng et al (2011) on cabbage.

Results of Table 1 also indicated that the treatment of Nano amino acid was increased plant content of nitrogen, potassium and zinc, which may be attributed to the direct supply of nitrogen by leaves as the amino acid contains nitrogen in its structure (Bidwell 1979). Nitrogen has major role in increasing plant growth and root system that helps in absorption mineral elements such as nitrogen, potassium and zinc (Barraclough et al 1989). In addition, spraying amino acid gave the plant opportunity to take advantage of it and increase vegetative growth and absorption of nutrients (Rai 2002), and this is in line with what El-Awad (2007) obtained on potato.

While, Table 2 results showed an increasing fruits content of carbohydrates, protein, vitamin C, Solanine and nitrate when it treated with Nano amino acid. This may be attributed to that amino acids such as Glycine considered one of basic part of proteins (Rai 2002). The increase in vitamin C occurred due to the increasing of fruits content of carbohydrates and the increase in the concentration of ascorbic acid (Al-Said and Kamal 2008).

The percentage of increasing in protein when spraying with zinc may be attributed to zinc role in providing elements including nitrogen and speed the transferring the products of photosynthesis which lead to increase nitrogen concentration in leaves and fruits (Khourgami and Fard 2012). Also increase eggplant fruits content of vitamin C when it treated with zinc as well as increase ascorbic acid in fruits (Zhang 2006). The interaction between Nano amino acids and zinc was increased the percentage of nitrate in fruits as it associated with gastrointestinal cancer through the reduction of nitrates in the digestive system to nitrite and after that its binds with amino compounds and turn into a carcinogen so called nitrous amine (Zeiger and Taiz 2006). The reason for the increase in nitrate content in eggplant fruits may be attributed to the role of nano amino acids in equilibrating the plant with nitrogen, which leads to good plant growth and accumulation may occur inside the plant beyond the permissible limit (Abo Rayan 2010).

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