Effect of growth regulator (ATONIK) and Zn-Nano-fertilizer on Yield and Physiological Parameters of sweet pepper

Mustafa Hameed Kadhum Al-Musawi1 Duaa Hayder2 Hameed Kadhum3
1College of Agriculture / Al-Qasim Green University
2Agriculture Ministry , Babylon
3Al-Furat Al-Awset University , Technical College Al-Mussiab
mustafa.hameed@agre.uoqasim.edu.iq

Abstract :
A field experiment was conducted in the non-heated plastic house at special field at (44° 27′ east 32° 35′ north) coordinate for the autumn season 2022 to study the response of sweet pepper (Qurtuba cultivar) *Capsicum annuum* L. to foliar spraying with growth regulator (Atonik) and Nano-zinc in sandy loam soil. A factorial experiment was designed according to RCBD design, and the average compared using LSD at significant level of 5%. The growth regulator (Atonik) at four levels (0, 25, 50, and 75 mg L^{-1}) and four levels of Nano-Zinc fertilizer (0, 2, 4, and 6 gm L^{-1}) with three replicates, the results indicated to the excelling of the spraying treatment by growth regulator at level (75 mg L^{-1}) which significantly increased the number of fruits per plant, fruit weight, early and total yield of plant, fruit vitamin C , total solube solid (T.S.S), total soluble phenols, and soluble saccharides with an average of (33.8 fruit , 81.5 gm , 0.70 kg , 2.80 kg , 52.60 mg 100gm^{-1} fresh weight , 8.63% , 5.83 mg gm^{-1} fresh weight , and 9.65%) for the above parameters sequentially. which is the same behavior as the spraying of Nano-Zinc at a concentration of (6 gm L^{-1}) for the parameters above with an average (33.9 fruit , 78.2 gm , 0.69 kg , 2.79 kg , 49.70 mg 100gm^{-1} fresh weight , 8.03% , 5.76 mg gm^{-1} fresh weight , and 9.23%) sequentially as compared to the control treatment. As for interaction treatments, it showed excelling the interaction spraying treatment (75 mg L^{-1} + 6 gm L^{-1}) by giving it the highest values for all the above parameters.
Keywords : Sweet peppers, Qurtuba, Atonik, Nano-Zn.

Introduction :

Sweet pepper (*Capsicum annuum* L.) is belonging to the Solonaceae family plan, its importance back to contain vitamins A and C as well as mineral elements such as calcium, iron and phosphorus. Also it contains proteins and carbohydrates. The use of foliar nutrients is a complementary method of soil fertilization, which is one of the highways to address the shortage of one of the important nutrients for plant growth. It is a process to ensures the homogeneous distribution of nutrient elements on plant vegetative growth as well as the high efficiency of this method in providing the plant in large quantities of the nutrient element [1]. [2] showed with increasing demand for food, the use of foliar fertilizers increased by spraying it on the total vegetative of plant for micro or macronutrients element which encouraged the production of large quantities of fertilizers at the commercial level. Scientific experiments have indicated that most plants respond to them. [3] noted that plant leaf is considered as an effective part in the photosynthesis processes and most of the phylogenetic processes occurring in the plant, for this lack of nutrient elements shows first in the leaves. In order to treat this condition, it is preferable to add fertilizers by foliar spraying because it is more availability and thus can play their role in the metabolism processes and fixation of substance in the cells, which is reflected in the impact of plant growth and development during its various stages of growth. [4] added that the addition of fertilizers spraying on the leaves of plants is necessary in the soils of Iraq, that are exposed to the washing and sedimentation and stabilization of nutrients elements, which requires spraying this fertilizer to secure the needs of plants of these nutrients. Iron and zinc have great importance in plant physiology. Iron has a role in the construction of chlorophyll and oxidation and reduction

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processes within the plant tissue, as well as in the synthesis of cytokines for photosynthesis processes [5] . While zinc plays an important role in building enzymes and proteins that contribute to cell division and metabolism of nucleic acids. It also contributes to the management of natural oxy and plant cell protection systems [6] .

As for plant growth regulators, including industrial auxins such as naphthalene acetic acid NAA, they lead to an increase in stem growth in length, and an increase in the plasticity and flexibility of plant cells, which leads to their elongation and steadily increasing their size and helps in the division of plant cells, with an increase in their protein content, and an increase in fluid flow into The cell, which leads to its rapid division and thus the growth of the plant by increasing the number of cells in its various tissues, the increase in amino acids leads to a decrease in the osmotic potential and in turn reduces the water potential of the cell, thus increasing the ability of the cell to withdraw water And the nutrients dissolved in it from the growth medium, and then increase the vegetative growth of plants [7] and. [8]. The use of the growth regulator Atonik at a concentration of 80 mg/L sprayed on tomato leaves led to an increase in the rate of plant height, the number of leaves, and the leaf area of the plant, as well as an increase in the concentration of NPK elements in the leaves. [9] indicated that the use of a commercial foliar amino acid (Tirasorb) at a concentration of 3 ml / to lead to a significant increase in the percentage of field emergence, the number of main stems, plant height, leaf area, relative chlorophyll content, and dry weight of the vegetative growth of potato. [10] indicated that the use of plant growth regulators sprayed on the leaves of the tomato plant, such as gibberellin, indole acetic acid, and naphthalene acetic acid, led to a decrease in the percentage of protein in the leaves and an increase in the level of chlorophyll in the leaf of the tomato plant compared to the untreated plants .[11] when studying the effect of amino acids (tyrosine, proline, arginine) on the growth of tomato plants (Htouf cultivar) found that the addition treatment of 200 mg / L gave the highest values with significant differences in the characteristics of plant height, average leaf area, dry shoot weight and dry root weight. Compared to the comparison transaction.

The use of Nano fertilizers is a modern technology in the process of plant fertilization. It helps to improve soil properties and activate its vital components. Adding them to plants in leaves fertilizers help increasing growth and productivity. The use of Zinc- Nano fertilizer in agriculture is more effective in terms of targeting their workplaces compared to the traditional compounds of this element, as well as the cost of less and use it reduces the harmful effects of the agricultural environment [12] . [13] pointed out that spraying with nano-zinc led to increase the yield of wheat and the concentration of (6 gm. L-1) as compared to the control treatment. [14] mentioned spraying different levels of zinc on the leaves of pepper which was grown in greenhouses. The concentration of (25 mg of zinc-1) led to a significant increase in the characteristics of the rate of plant height and number of branches, the number of flowers and the proportion of the contract also achieved the characteristics of the number of fruits and their weight increased significantly by 32 and 29% sequentially as compared to the control treatment. This was reflected on the plant yield, the early and total yield of the plastic house, which achieved a significant increase of 74, 49 and 73% sequentially in comparison.

The study aims to determine sweet pepper plant to foliar spraying with two types of iron and zinc Nano fertilizers and their effect on the indicators of vegetative growth and NPK uptake by plant leave.

Materials and Methods

A field experiment was conducted in the non-heated plastic house at special field at (44° 27′ east 32° 35′ north coordinate) for the autumn season 2022 to study the response of sweet pepper *Capsicum annuum* L. Qurtuba cultivar to foliar spraying with two types of zinc and iron Nano fertilizers. Random samples were

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taken from three areas with a depth of 0-30 cm. The samples were mixed well. A sample was taken for analysis in the special laboratory of the special sectors under the methods mentioned by [15] and [16] . Table 1. Show the characteristic of soil, the land of the plastic house was divided after the sterilization to 50 plots, the width of each of them 150 cm (the width of the channel plot is 50 meters while the width of the walkway was 100 cm). The plots were irrigated two days before cultivated, the produced seedlings were cultivated in one of the private farms in the region (with 40 days age and after the formation of 3-4 real leaves) on both sides of the plots on 15/10/2022 with distance of 40 cm between them, and 10 plants were taken to the experimental unit. The irrigation system was set up above the walkway of the plot and at a distance of 10 cm from the seedling site and left at a distance of (1 m) at the beginning and end of the plastic house. The service operations were performed such as replanting, grubbing and pruning for all experimental units. The mineral fertilizer was added with an average of (240 kg donum^{-1}) of ammonium sulphate and (160 kg donum^{-1}) of triple superphosphate on two batches during vegetative and flowering growth, as flowering in the crop cultivation in greenhouses [17] . The study included 16 treatments of compatibility between two factors. The first factor included of four concentrations of growth regulator (Atonik) which (0, 25, 50, and 75 mg L^{-1}). While the second factor included four concentrations of the Nano-zinc fertilizer (0 , 2 , 4 , 6 gm L^{-1}). The spraying process was conducted with rate of five times, the period between them was over 20 days. The first spraying was on 20/11/2022 before the flowers appeared. The spraying process was conducted in the early morning preceded by the field irrigation in the previous day to ensure the opening of the stoma. The experiment was conducted according to the Randomized Complete Block Design (RCBD) with three replicates. The results were analyzed using the least significant difference (L.S.D) at the 5% probability level according to[18]

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Table 1. Soil characteristics used in the experiment*

Value	Unit	الصفة
2.3	ds m^{-1}	Ece
7.6	---	pH
8.7	gm kg^{-1}	Organic matter
15.7	Cmole kg^{-1} soil	CEC
19.6	gm kg^{-1}	$CaCO_3$
23.8	mg kg^{-1}	Available N
6.3		Available P
54.6		Available K
1.38	gm cm^{-3}	bulk density
588.4	gm kg^{-1}	Sand
243.5		Silt
168.1		Clay
Sandy loam		Texture

*soil analysis was done in laboratory of agriculture college/Baghdad university

Six plants were selected randomly selected from each experimental unit and marked with the purpose of recording data which was number of fruit per plant , fruit weight , early plant yield , total plant yield , fruit vitamin C according to [19] by titration with 2-6-dichloro phynol indophynol , total solube salt (T.S.S) by using refrectometer, total soluble phenols according to [20] by using Arnows reagent , and soluble saccharides according to [21] .

Results and Discussion

1-Average number of fruits and weight of fruit:

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Table 2 showed that there were significant differences between the levels of foliar spraying for pepper plant with growth regulator (Atonik) and Nano-Zinc in fruit number in the plant and the weight of fruit as compared to the control treatment. The treatment of growth regulator spraying with a concentration (75 mg L^{-1}) gave the highest values to the two parameters above, as it was (33.8 fruit and 81.5 gm) sequentially compared to the control treatment, which gave the lowest averages of (25.6 fruit and 55.1 gm) sequentially. The same table showed that the spraying of with Nano-Zn element led to a significant increase in these two parameters above when using spraying treatment (6 gm. L^{-1}) which was excelled by giving the highest average which is amounted of (33.9 fruit and 78.2 gm) compared to the control treatment which gave the lowest averages (25.3 fruit and 56.4 gm) sequentially. The results of the data analysis showed that the interaction between the two factors had a significant effect on the increase in the average fruit number in the plant and the weight of fruit, the spraying treatment (75 mg L^{-1} + 6 gm L^{-1}) gave the highest values amounted to (39.7 fruit and 95.5 gm) sequentially, on the other hand, the lowest average for these two parameters was at the treatment without spraying with the two factors.

Table 2. Effect of growth regulator and Nano-Zn fertilizer on plant fruit number and fruit weight

Growth R. mg L^{-1}	No. of fruit per plant				Aver.	Fruit weight gm				Aver.
	Nano-Zn gm L^{-1}					Nano-Zn gm L^{-1}				
	0	2	4	6		0	2	4	6	
0	21.5	24.4	27.2	29.4	25.6	48.6	51.2	57.3	63.4	55.1
25	24.3	27.7	30.3	32.1	28.6	49.9	54.5	59.6	70.1	58.5
50	26.4	31.4	33.7	34.5	31.5	58.4	65.2	76.3	83.7	70.9
75	29.1	29.8	36.4	39.7	33.8	68.7	76.1	85.6	95.5	81.5
Aver.	25.3	28.3	31.9	33.9		56.4	61.8	69.7	78.2	
G.R 1.78	Nano-Zn 1.78		Interaction 3.56		G.R 5.42	Nano-Zn 5.42		Interaction 10.82		LSD*0.05*

2-Average of early and total yield for the plant: Table 3 showed that there were significant differences between the levels of foliar spraying for pepper plant with growth regulator (Atonik) and Nano-Zinc in average of plant early and total yield as compared to the control treatment. The treatment of growth regulator spraying with a concentration (75 mg L^{-1}) gave the highest values to the two parameters above, as it was (0.70 kg and 2.80 kg) sequentially compared to the control treatment, which gave the lowest averages of (0.50 kg and 2.08 kg) sequentially. The same table showed that the spraying of with Nano-Zn element led to a significant increase in these two parameters above when using spraying treatment (6 gm. L^{-1}) which was excelled by giving the highest average which is amounted of (0.69 kg and 2.79 kg) compared to the control treatment which gave the lowest averages (0.50 kg and 2.09 kg) sequentially. The results of the data analysis showed that the interaction between the two factors had a significant effect on the increase in the average plant early and total yield, the spraying treatment (75 mg L^{-1} + 6 gm L^{-1}) gave the highest values amounted to (0.79 kg and 3.21 kg), sequentially, on the other hand, the lowest average for these two parameters was at the treatment without spraying with the two factors.

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Table 3. Effect of growth regulator and Nano-Zn fertilizer on early yield and total yield

Growth R. mg L^{-1}	Early Yield kg $plant^{-1}$				Aver.	Total Yield kg $plant^{-1}$				Aver.
	Nano-Zn gm L^{-1}					Nano-Zn gm L^{-1}				
	0	2	4	6		0	2	4	6	
0	0.42	0.49	0.52	0.58	0.50	1.67	1.96	2.27	2.43	2.08
25	0.47	0.58	0.62	0.67	0.59	1.98	2.25	2.48	2.63	2.34
50	0.53	0.57	0.67	0.71	0.62	2.21	2.34	2.67	2.89	2.53
75	0.56	0.68	0.75	0.79	0.70	2.48	2.63	2.87	3.21	2.80
Aver.	0.50	0.58	0.64	0.69		2.09	2.30	2.57	2.79	
G.R	Nano-Zn		Interaction			G.R	Nano-Zn		Interaction	LSD*0.05*
0.07	0.07		0.14			0.21	0.21		0.42	

3-Average of Vitamin C and T.S.S in fruits

Table 4 showed that there were significant differences between the levels of foliar spraying for pepper plant with growth regulator (Atonik) and Nano-Zinc in average of vitamin C and total solube solid in fruits as compared to the control treatment. The treatment of growth regulator spraying with a concentration (75 mg L^{-1}) gave the highest values to the two parameters above, as it was (52.60 mg 100 gm^{-1} fresh weight , 8.63%) sequentially compared to the control treatment, which gave the lowest averages of (37.30 mg 100 gm^{-1} fresh weight , 5.93%) sequentially. The same table showed that the spraying of with Nano-Zn element led to a significant increase in these two parameters above when using spraying treatment (6 gm. L^{-1}) which was excelled by giving the highest average which is amounted of (49.70 mg 100 gm^{-1} fresh weight , 8.03%) compared to the control treatment which gave the lowest averages (39.95 mg 100 gm^{-1} fresh weight , 6.58%) sequentially. The results of the data analysis showed that the interaction between the two factors had a significant effect on the increase in the average plant early and total yield, the spraying treatment (75 mg L^{-1} + 6 gm L^{-1}) gave the highest values amounted to (56.7 mg 100 gm^{-1} fresh weight , 9.8%), sequentially, on the other hand, the lowest average for these two parameters was at the treatment without spraying with the two factors.

Table 4. Effect of growth regulator and Nano-Zn fertilizer on vitamin C and T.S.S.

Growth R. mg L^{-1}	Vitamin C mg $100gm^{-1}$ f.w.				Aver.	Total soluble solid %				Aver.
	Nano-Zn gm L^{-1}					Nano-Zn gm L^{-1}				
	0	2	4	6		0	2	4	6	
0	34.2	35.1	37.8	42.1	37.30	5.3	5.7	6.2	6.5	5.93
25	36.6	38.4	43.5	47.9	41.60	6.1	6.7	7.1	7.4	6.83
50	40.2	45.6	49.4	52.1	46.83	7.2	7.5	7/9	8.4	7.75
75	48.8	51.2	53.7	56.7	52.60	7.7	8.3	8.7	9.8	8.63
Aver.	39.95	42.58	46.10	49.70		6.58	7.05	7.48	8.03	
G.R	Nano-Zn		Interaction			G.R	Nano-Zn		Interaction	LSD*0.05*
2.07	2.07		4.14			0.36	0.36		0.72	

4-Average of total soluble phenol and soluble saccharides in fruits

Table 5 showed that there were significant differences between the levels of foliar spraying for pepper plant with growth regulator (Atonik) and Nano-Zinc in average of total soluble phenol and soluble saccharides in fruits as compared to the control treatment.

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The treatment of growth regulator spraying with a concentration (75 mg L^{-1}) gave the highest values to the two parameters above, as it was () sequentially compared to the control treatment, which gave the lowest averages of (5.83 mg gm^{-1} fresh weight , 9.65%) sequentially. The same table showed that the spraying of with Nano-Zn element led to a significant increase in these two parameters above when using spraying treatment (6 gm. L^{-1}) which was excelled by giving the highest average which is amounted of (5.76 mg gm^{-1} fresh weight , 9.23%) compared to the control treatment which gave the lowest averages (4.66 mg gm^{-1} fresh weight , 7.97%) sequentially. The results of the data analysis showed that the interaction between the two factors had a significant effect on the increase in the average plant early and total yield, the spraying treatment (75 mg L^{-1} + 6 gm L^{-1}) gave the highest values amounted to (6.78 mg gm^{-1} fresh weight , 10.89%), sequentially, on the other hand, the lowest average for these two parameters was at the treatment without spraying with the two factors.

Table 5. Effect of growth regulator and Nano-Zn fertilizer total soluble phenol and soluble saccharides in fruits.

Growth R. mg L^{-1}	total soluble phenol mg gm^{-1}				Aver.	soluble saccharides %				Aver.
	Nano-Zn gm L^{-1}					Nano-Zn gm L^{-1}				
	0	2	4	6		0	2	4	6	
0	4.22	4.36	4.58	5.12	4.57	7.42	7.85	8.03	8.25	7.89
25	4.43	4.67	4.82	5.25	4.79	7.56	7.92	8.15	8.42	8.01
50	4.87	4.95	5.36	5.89	5.27	8.17	8.66	9.12	9.34	8.82
75	5.11	5.48	5.93	6.78	5.83	8.72	9.25	9.73	10.89	9.65
Aver.	4.66	4.87	5.17	5.76		7.97	8.42	8.76	9.23	
G.R 0.26	Nano-Zn 0.26		Interaction 0.52		G.R 0.43	Nano-Zn 0.43		Interaction 0.86		LSD*0.05*

Table (2 , 3, 4 , 5) shows a significant increase in the number of fruits, fruit weight , early and total yield , Vitamin C , T.S.S , total soluble phenol , and total saccharides with an average of (33.8 fruit , 81.5 gm , 0.70 kg , 2.80 kg , 52.60 mg 100gm^{-1} fresh weight , 8.63% , 5.83 mg gm^{-1} fresh weight , and 9.65%) for the above parameters sequentially due to the spraying nano-zinc and growth regulator . This can be attributed to the role of Nano-nutrients zinc in the synthesis and activation of many enzymes necessary for the Bio-processes in the plant as well as control the hormonal balance of the plant and this is the increase in the indicators of vegetative growth, which is reflected on the yield plant [22] . The results of the statistical analysis showed that the interaction between the factors led to a significant increase in all indicators of vegetative growth and the yield studied. This may due to the combined effect of iron and zinc fertilizers used in the experiment.

Conclusion

From result of studied plant parameters it concluse that the growth regulator at 75 mg l^{-1} increase all growth and yield parameter of pepper plant , such as the treatment of spraying with 6 gm l^{-1} zinc gave a highest value of plant parameters comparing with no spraying treatment.

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