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Effect of Bio-FertilizerNano Iron and Chelating Iron on Cayenne Pepper Leaf

Duaa M. Abdul-Alhur [1,a,*] , Hassan Hadi Alkarawi [1,b]
[1] Soil and Water Technologies Department, Al- Mussaib Technical College , Al-Furat Al-Awsat Technical University, Iraq
[a] duaa94maytham@gmail.com
[b] Hassan.alkarawi@atu.edu.iq
[*]Corresponding author: duaa94maytham@gmail.com

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Abstract. *An experiment was carried out inside the plastic tunnels of the 2019-2020 season to study the effect of three methods of treating Bio- fertilizer and three levels of both Nano iron and chelated iron on the content of chili leaves of nitrogen, phosphorous, potassium, iron, zinc and manganese, in a factorial experment with a design RCBD in three Replicates and the experiment factors included (seed pollination, dipping seedlings, and soil injection with bio fertilizer), (0, 0.75, 1.5 gm. L^{-1} of Nano-iron) and (0, 5, 10 gm. L^{-1} of chelated iron). The results indicated that: The treatment of nano iron (1.5 gm.L^{-1}) was significantly higher by giving the highest averages of nitrogen, phosphorous, potassium, iron, zinc and manganese elements absorbed by plant leaves, which amounted to (3.13% '0.40%, 2.3%, 110.31 gm.kg^{-1}, 15.02 gm. kg^{-1}, 51.38 gm.kg^{-1}) respectively, while the treatment of chelated iron (10 gm. L^{-1}) was significantly superior and gave the highest averages for the above elements as (2.95%, 0.38%, 2.09%, 94.86 gm.kg^{-1}). 13.55 gm. kg^{-1}, 45.60 gm. kg^{-1}) respectively, and the treatment of bio fertilizer (injection into the soil) significantly outperformed with the highest averages reaching (2.92%, 0.39%, 2.15%, 96.64 gm. kg^{-1}, 13.86 gm. kg^{-1}, 47.10 gm. kg^{-1}) respectively.*

Keywords: *Bio-fertilizer; Nano Iron; chelating Iron; chili.*

1. INTRODUCTION

Cayenne pepper is one of the important summer crops of the Solanaceae family. It needs a mild climate heats and does not tolerate cold much, and frosts kill the plants. Tropical countries are famous for their production, such as India, Indonesia, Myanmar, Bangladesh, Pakistan, and Thailand [1]. Every 100 grams of green chili pepper contains 85.7 grams of water, 6.8 grams of fiber, 3 grams of carbohydrates, 2.9 grams of protein, 0.6 grams of fat, 217 mg potassium, 80 mg phosphorus, 30 mg calcium, 24 mg magnesium, and 4.4 mg iron 6.5 mg sodium, 116 calories, 400-500 international units of vitamin A, 0.19 mg thiamine, 0.39 mg riboflavin, 0.5 mg niacin, 111 mg vitamin [2], The nutritional value of cayenne pepper is characterized by the fruits containing an effective alkaloid group called Capsaicinoids, which have a spicy taste, and the most famous of its compounds is Droxypropine Prosidol Zucapsaicin (Capsaicin C18H27NO3), which made its fruits used in many foods and food industries in countries of the world [3].

Biofertilizers are a group of micro-organisms or any addition of biological origin to the soil, seeds, or both in order to supply the plant with its nutritional needs, and sometimes called microbial inoculants. Using biological fertilization has spread recently in many areas of the Arab world through Adding some beneficial and efficient microbes or using them as bacterial or fungal biological fertilizers or both together and bio-fertilizers help to increase production as the amount of increase in the resulting yield can reach over 40% and the bio-fertilizers its increase the crop content of nutrients and energy compounds compared to mineral fertilizers besides the low costs of producing bio-fertilizers, this increases the profit and income of the farmer and the investor. Using mineral fertilizers often leads to harmful environmental

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effects, including washing of nitrates into the groundwater, so there is a need for a nutrient management system to maintain productivity, such as a bio- fertilizer, including bacteria. Root fungi are among the successful alternatives in increasing nutrient readiness and stimulating plant growth [4],[5],[6].
The Trichoderma harzianum fungus is one of the deficient fungi that live restoratively on organic matter and included in the PGPF group and are present in the rhizosphere and significantly affect plant growth because of its high ability to colonize the root zone and secrete many organic compounds that contribute to stimulating plant growth and reducing the soil pH, which leads to an increase in the readiness and absorption of some important micronutrients such as iron and manganese and besides their excretion of many biochemical compounds [7] that involved in the processes of plant metabolism and contribute to the regulation and increase of plant growth and secrete compounds inhibit the growth of pathogens [8]. Foliar nutrition is one of the most important methods of supplying plants with their needs for nutrients. Micro-nutrients such as copper, zinc, manganese, and iron play a vital role in improving the yield, and are necessary to increase plant growth. Micronutrients exposed day after day to the loss from the soil because of relying on industrial fertilizers and poor soil management to get a greater yield [9], therefore, the need to use leaf nutrition instead of ground fertilizer required where the trace elements are loss in different ways due to inappropriate soil pH. , these elements undergo to adsorption and sedimentation reactions, thus forming compounds that are not ready for absorption by the roots of plants [10].
Nano fertilizers are one of the important methods in agriculture to improve crop growth averages by increasing productivity and improving quality, [11], as one of the most important objectives of agricultural policy in any country in the world is to improve production and increase the agricultural products, in order to meet the needs of the ever-growing population,. Increasing the efficiency of using materials or resources with minimal damage it can do to production through the use of modern technology in agriculture. Among these technologies, nanotechnology has the potential to revolutionize agricultural systems, biomedicine, environmental engineering, safety, security, water resources, and energy conversion. And many other fields [12] ,[13] ,[14].
The study aims to find out the effect of iron fertilizers with the quality of Nanoparticles and chelation and biol fertilizers in the absorption of nutrients by the leaves of chili.

2. MATERIALS AND METHODS

The experiment was carried out during fall, 2019/2020 in one of the plastic fields of the ARD company's Rasheed station in the Yusufiya area. The site is at a latitude of 33 ° 7` north, longitude 44 ° 23 ° west, and at an altitude of 34 m above Sea Level . The aim of study is knowing the effect of Nano iron fertilizer, chelated iron fertilizer, and inoculation with Bio-fertilizer , and the interaction between them in the growth and yield of c components (Algae Extract "Ascophyllum nodosum" 10% , Trichoderma harzianum 10^6cfu/g , Bacillus subtilis 10^7cuf/g , Potassium –Humates 75% ,Total Humic Acids $^{1/2}$ 66-68% , Humic Acid ^{1} 61-62 % , Fulvic Acid ^{1} 5-6% , Potassium (k_2o) 10-12% , Dry Matter 83-85% , Organic Substance 68-70 % , pH – value 9.5-10.5 , Bulk Density 0.55 – 0.65 kg/L hili pepper hybrid (Berberine variety) produced from the Italian UG company and registered with the Iraqi Ministry of Agriculture.
The experiment land plowed with a tipping plow, perpendicular plowing three times in succession to get well-loosened soil with disc harrows, after which it was flattened and divided into three tunnels (replicates), since the area of one tunnel is 45 m2 (the length of one tunnel is 18 m and its width is 2.5 m), soil samples was collected From different areas of the field belonging to the ARD company, randomly and to a depth (0-30 cm), soil samples was dried by air, then it was mixed well to homogeneity and a single compound sample taken and some chemical and physical characteristics estimated before planting as shown in Table (1). It was added phosphate fertilizer when preparing the land for cultivation, with an

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amount of triple superphosphate (P% 48) at a rate of 150 ($kg.h^{-1}$), it was mixed it in one batch with the soil before planting. It was added fertilizer N and K after planting (100 kg. E $^{-1}$) potassium In the form of potassium sulfate fertilizer (42% K), nitrogen was added by 160 kg. N^{-1} as urea fertilizer (46% N) in two batches, the first batch after two weeks of planting and the second 45 days after the first batch, according to the quantity recommended [15]. The hot pepper seeds was sowed plant in 9/15/2019 in coral plates with a capacity of 209 seeds, and the seedlings wastransferred to the sustainable field into the tunnels in 11/3/2019 after they reached the size 4 real leaves. On both sides of the terrace, the first irrigation took place and the experimental unit included (8) plants. Bio-fertilizer treatments was used with three methods , treatment the seeds before planting with the Bio-fertilizer preparation according to the recommendations of the producing company, and mixed the bio-fertilizer with the planting medium , dipped Seedlings roots with bio- fertilizer for 10 minutes before being transferred to the tunnels with the addition of gum Arabic to ensure the adhesion of the bio- fertilizer to the seeds, then they remain in the shade for 15 minutes before planting. Bio-fertilizer treatments was at a concentration of 10 g. L^{-1} water. 216 seedlings were treated with with the bio- fertilizer in (18/11/2019). Chili plants harvested on (5/11/2020).The study factors represented 3 levels of Nano fertilizer, which are (0, 0.75, 1.5 gm. L^{-1}) and three levels of chelated iron are (0, 5, 10 $gm.L^{-1}$) Three methods of adding bio- fertilizer are seed soak , dipping seedlings and injecting into the soil. A factorial experiment with complete randomized design(CRD) was used with three replications, and it compared the averages using the least significant difference test(LSD) according to the method [16]The elements of nitrogen, phosphorous, potassium, iron, manganese, and zinc was extracted by using digesting, the vegetable tissue used with 0.2 g of the plant sample using sulfuric acid and perchloric acid in a ratio of 3: 5 and according to the method suggested by[17] After completing the digestion process the elements were estimated as a percentage, according to the methods mentioned in [18] ,[19].

Table 1. Characteristics of study soil

Soil characteristics	Value	Unit
Electrical conductivity (1:1)	3.3	$ds.m^{-1}$
pH (1:1)	7.17	--
Cation Exchange Capacity (CEC)	26.1	$Cmole.kg^{-1}$
Organic mater	12.1	$gm.kg^{-1}$
$CaSO_4$	2.30	
$CaCO_3$	250	
Available N	28.13	$mg.kg^{-1}$
Available P	5.21	
Available K	195.71	
Available Fe	3.80	
Available Mn	5.36	
Available Zn	3.31	
Sand	340	$gm.kg^{-1}$
Silt	444	
Clay	216	
Texture	Loam	

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3. RESULTS AND DISCUSSION

3.1. RESULTS

3.1.1. Leaf nitrogen content %:

The results of Table (2) showed significant differences in the effect of the studied factors in nitrogen content in the leaves , the treatment of nano iron (N2) gave the highest average nitrogen in the papers of (3.13%), while the comparison treatment (N0) gave the lowest average it reached (2.51%), the spraying with chelating iron treatment, (F2) gave the highest average of (2.95%) compared to the treatment (F0), which gave the lowest average of (2.67%), the adding of bio- fertilizer treatment (B3) achieved a significant increaseit gave the highest average (2.92%) compared to the treatment (B1), which gave the lowest average (2.66%). the treatments of dual interaction between nano iron and chelated iron (N2F2) gave the highest average (3.43%) compared to the treatment (N0F0), which gave the lowest average (2.46%) The treatment gave reached (3.30%) compared to the treatment (N0B1) which gave the lowest value (2.44%), while the treatment (F2B3) showed a significant superiority and recorded the highest value amounting to (3.13%) compared to the treatment (F0B1) which recorded the lowest value (2.56%). The treatment of triple interaction between nano iron, chelated iron and bio- fertilizer, (B3N2F2) recorded the highest value (3.73%) compared to the treatment (B1N0F0) which recorded the lowest value (2.33%).

Table 2. Effect of nano iron , chelating iron, and Biofertilizer on N content in leaves %

Nano-Iron gm.L^{-1}	Chelating Iron	Bio-fertilizer			Average
		Seed pollination	Seedlings are pollinated	Soil injection	
0	0	2.33	2.40	2.63	2.46
	5	2.47	2.43	2.53	2.48
	10	2.53	2.57	2.67	2.59
0.75	0	2.57	2.67	2.70	2.64
	5	2.63	2.73	2.83	2.73
	10	2.70	2.77	2.99	2.82
1.5	0	2.77	2.93	3.00	2.90
	5	2.87	3.13	3.17	3.06
	10	3.07	3.50	3.73	3.43
LSD0.05		0.139			0.080
Nano Iron * Biofertilizer					
0		2.44	2.47	2.61	2.51
0.75		2.63	2.72	2.84	2.73
1.5		2.90	3.19	3.30	3.13
LSD0.05		0.080			0.046
Chelating Iron * Biofertilizer					
0		2.56	2.67	2.78	2.67
5		2.66	2.77	2.85	2.76
10		2.77	2.94	3.13	2.95
LSD0.05		0.080			0.046
average		2.66	2.79	2.99	
LSD0.05		0.046			

3.1.2. Phosphorus content in leaves %

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The results of Table (3) showed significant differences in the effect of the studied factors in the phosphorous percentage in the leaves, as the treatment of nano iron (N2) outperformed and gave the highest average for phosphorous in the papers (0.40%), while the comparison treatment (N0) gave the lowest average it reached (0.32%). The spraying with chelating iron treatment (F2) gave the highest average (0.38%) compared to the treatment (F0), which gave the lowest average (0.34%). The addition of bio- fertilizer (B3) achieved a significant increase it gave the highest average (0.39%) compared to the treatment (B1) which gave the lowest average (0.34%). The treatments of dual interaction between nano iron and chelated iron (N2F2) and gave the highest average (0.42%) compared to the treatment (N0F0) which gave the lowest average (0.29%). The treatment gave (0.43%) compared to the treatment (N0B1) which gave the lowest value (0.30%), while the treatment (F2B3) showed a significant superiority and recorded the highest value amounting (0.41%) compared to the treatment (F0B1) that recorded the lowest value (0.31%). The treatment of triple interaction between nano iron , chelated iron and bio- fertilizer (B3N2F2) recorded the highest value (0.45%) compared to the treatment (B1N0F0), which recorded the lowest value (0.28%).

Table 3. Effect of nano iron, chelating iron, and biofertilizer on P content in leaves %

Nano-Iron gm.L^{-1}	Chelating Iron	Bio-fertilizer			Average
		Seed pollination	Seedlings are pollinated	Soil injection	
0	0	0.28	0.29	0.31	0.29
	5	0.31	0.34	0.35	0.33
	10	0.32	0.36	0.37	0.35
0.75	0	0.30	0.35	0.36	0.34
	5	0.34	0.36	0.39	0.36
	10	0.35	0.39	0.42	0.38
1.5	0	0.36	0.40	0.41	0.39
	5	0.38	0.41	0.42	0.40
	10	0.39	0.42	0.45	0.42
LSD0.05		0.012			0.007
Nano Iron * Biofertilizer					
0		0.30	0.33	0.34	0.32
0.75		0.33	0.36	0.39	0.36
1.5		0.37	0.41	0.43	0.40
LSD0.05		0.007			0.004
Chelating Iron * Biofertilizer					
0		0.31	0.35	0.36	0.34
5		0.34	0.37	0.38	0.37
10		0.35	0.39	0.41	0.38
LSD0.05		0.007			0.004
Average		0.34	0.37	0.39	
LSD0.05		0.004			

3.1.3. Potassium content in leaves %

The results of Table (4) showed that there are significant differences in the effect of the studied factors in the potassium's percentage in the leaves, as the treatment of nano iron (N2) gave the highest average for potassium in the leaves (2.30%), while the comparison treatment (N0) gave the lowest average it reached (1.70%) , the spraying with chelated iron treatment (F2) gave the highest average (2.09%) compared to

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the treatment (F0) which gave the lowest average (1.88%). The treatment of adding bio- fertilizer (B3) achieved a significant increase as it gave the highest average (2.15%) compared to the treatment (B1) which gave the lowest average (1.71%). The treatments of dual interaction between nano iron , chelated iron (N2F2) gave the highest average (2.42%) compared to the treatment (N0F0) which gave the lowest average (1.67%). The treatment gave reached (2.60%) compared to the treatment (N0B1) which gave the lowest value (1.66%), while the treatment (F2B3) showed a significant superiority and recorded the highest value amounting (2.29%) compared to the treatment (F0B1) that recorded the lowest value (1.69%).). The treatment of triple interaction between Nano iron, chelated iron and bio- fertilizer (B3N2F2) recorded the highest value (2.75%) compared to the treatment (B1N0F0), which recorded the lowest value (1.65%).

Table 4. Effect of nano iron, chelating iron, and biofertilizer on K content in leaves %

Nano-Iron gm.L^{-1}	Chelating Iron	Bio-fertilizer			Average
		Seed pollination	Seedlings are pollinated	Soil injection	
0	0	1.65	1.67	1.68	1.67
	5	1.66	1.70	1.72	1.69
	10	1.67	1.74	1.77	1.73
0.75	0	1.69	1.83	1.86	1.79
	5	1.70	1.94	2.22	1.95
	10	1.71	2.28	2.36	2.12
1.5	0	1.74	2.38	2.44	2.18
	5	1.79	2.55	2.60	2.31
	10	1.82	2.68	2.75	2.42
LSD*0.05*		0.030			0.018
Nano Iron * Biofertilizer					
0		1.66	1.70	1.72	1.70
0.75		1.70	2.02	2.14	1.95
1.5		1.78	2.54	2.60	2.30
LSD*0.05*		0.018			0.010
Chelating Iron * Biofertilizer					
0		1.69	1.96	1.99	1.88
5		1.72	2.06	2.18	1.99
10		1.73	2.23	2.29	2.09
LSD*0.05*		0.018			0.010
Average		1.71	2.09	2.15	
LSD*0.05*		0.010			

3.1.4. Iron content in leaves mg.kg^{-1}

The results of Table (5) showed significant differences in the effect of the studied factors of iron content in the leaves, as the treatment of nano iron (N2) gave the highest average which amounted to 110.31 (mg.kg^{-1}) while the comparison treatment (N0) gave the lowest average (67.48 mg.kg^{-1}), the treatment of chelated iron spraying, (F2) gave the highest average (94.86 mg.kg^{-1}) compared to the treatment (F0), which gave the lowest average (84.82 mg.kg-1). The treatment of adding bio- fertilizer (B3) achieved a significant increase, as it gave the highest average (96.64 mg. kg^{-1}) compared to treatment (B1),which gave the lowest average (80.52 mg.kg^{-1}).

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Table 5. Effect of nano iron, chelating iron, and biofertilizer on Fe content in leaves mg.kg^{-1}

Nano-Iron gm.L^{-1}	Chelating Iron	Bio-fertilizer			Average
		Seed pollination	Seedlings are pollinated	Soil injection	
0	0	65.37	65.93	66.50	65.93
	5	65.73	66.20	66.90	66.28
	10	66.57	67.50	76.60	70.22
0.75	0	78.60	80.40	87.77	82.26
	5	81.80	96.73	98.67	92.40
	10	87.77	102.40	109.70	99.96
1.5	0	88.40	113.60	116.80	106.27
	5	94.17	114.87	121.73	110.26
	10	96.27	121.83	125.13	114.41
LSD*0.05*		5.510			3.181
Nano Iron * Biofertilizer					
0		65.89	66.54	70.00	67.48
0.75		82.72	93.18	98.71	91.54
1.5		92.94	116.77	121.22	110.31
LSD*0.05*		3.181			1.837
Chelating Iron * Biofertilizer					
0		77.46	86.64	90.36	84.82
5		80.57	92.60	95.77	89.64
10		83.53	97.24	103.81	94.86
LSD*0.05*		3.181			1.837
Average		80.52	92.16	96.64	
LSD*0.05*		1.837			

The treatments of dual interaction between nano iron , chelated iron ((N2F2) gave the highest average (114.41 mg. kg^{-1}) compared to the treatment (N0F0), which gave the lowest average (65.93 mg. kg^{-1}), and the treatment (N2B3) was significant, as it recorded the highest value (121.22 mg. kg^{-1}) compared to the treatment (N0B1), which gave the lowest value (65.89 mg. kg-1), while the treatment (F2B3) showed a significant superiorityand it recorded the highest value (103.81 mg. kg^{-1}) compared to the treatment (F0B1) which recorded the lowest value (77.46 mg. kg^{-1}). The treatment of triple interaction between Nano iron, chelated iron and bio-fertilizer , (B3N2F2) recorded the highest value (125.13 mg. kg^{-1}) compared to the treatment (B1N0F0) which recorded the lowest value (65.37 mg. kg^{-1}).

3.1.5. Manganese Content in leaves mg.kg^{-1}

The results of Table (6) showed that there are significant differences in the effect of the studied factors of manganese content in the leaves, as the treatment of nano iron (N2) gave the highest average of manganese in the leaves (51.38 mg.kg^{-1}), while the comparison treatment (N0) given the lowest average (36.67 mg.kg^{-1}),the treatment of chelating iron spraying (F2) gave the highest average f (45.60 mg.kg^{-1}) compared to the treatment (F0) which gave the lowest average (40.77 mg).

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Table 6. Effect of nano iron, chelating iron, and biofertilizer on Mn content in leaves mg.kg^{-1}

Nano-Iron gm.L^{-1}	Chelating Iron	Bio-fertilizer			Average
		Seed pollination	Seedlings are pollinated	Soil injection	
0	0	10.53	10.63	10.83	10.67
	5	10.67	10.87	11.07	10.87
	10	10.73	11.67	11.80	11.40
0.75	0	10.83	11.73	12.27	11.61
	5	11.07	12.73	13.70	12.50
	10	11.67	14.43	14.70	13.60
1.5	0	12.04	14.93	15.93	14.30
	5	12.17	16.23	16.91	15.10
	10	12.30	17.10	17.57	15.66
LSD*0.05*		0.325			0.188
Nano Iron * Biofertilizer					
0		10.64	11.06	11.23	10.98
0.75		11.19	12.97	13.56	12.57
1.5		12.17	16.09	16.80	15.02
LSD*0.05*		0.188			0.108
Chelating Iron * Biofertilizer					
0		11.13	12.43	13.01	12.19
5		11.30	13.28	13.89	12.82
10		11.57	14.40	14.69	13.55
LSD*0.05*		0.188			0.108
Average		11.33	13.37	13.86	
LSD*0.05*		0.108			

The treatment of adding bio- fertilizer (B3) achieved a significant increase, as it gave the highest average (47.10 mg.kg^{-1}) compared to treatment (B1) which gave the lowest average (38.16 mg.kg^{-1}). The treatments of dual interaction between nano iron, chelated iron (N2F2) gave the highest average (54.44 mg. Kg^{-1}) compared to the treatment (N0F0) which gave the lowest average (35.83) mg. Kg^{-1}, and the treatment affected(N2B3) (significantly), as it recorded the highest value (57.96 mg. Kg^{-1}) compared to treatment (N0B1) which gave the lowest value (35.72) mg. Kg^{-1}, while treatment (F2B3) showed a significant superiority and recorded the highest value (50.04) (mg. kg^{-1}) compared to treatment (F0B1) which recorded the lowest value (37.11) mg.kg^{-1}. The treatment of the triple interaction between nano iron, chelated iron and bio-fertilizer (B3N2F2) recorded the highest value (60.87) mg.kg^{-1}Compared to the treatment (B1N0F0) which recorded the lowest value (35.47) mg.kg^{-1}.

3.1.6. Zinc content in leaves mg.kg^{-1}

The results of Table (7) showed that there are significant differences in the effect of the studied factors of zinc content in the leaves, as the treatment of nan iron (N2) gave the highest average of zinc in the leaves (15.02 mg.kg^{-1}), while the comparison treatment (N0) gave the lowest average (10.98 mg. kg^{-1}), the treatment of spraying with chelated iron (F2) gave the highest average (13.55 mg. kg-1) compared to the treatment (F0) which gave the lowest average (12.19 mg.kg^{-1}). The treatment of adding bio-l fertilizer (B3) achieved a significant increase, as it gave the highest average (13.86 mg. kg^{-1}) compared to treatment (B1) which gave the lowest average (11.33 mg. kg^{-1}). The treatments of dual interaction between nano iron ,

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Table 7. Effect of nano iron, chelating iron, and biofertilizer on Zn content in leaves mg.kg^{-1}

Nano-Iron gm.L^{-1}	Chelating Iron	Bio-fertilizer			Average
		Seed pollination	Seedlings are pollinated	Soil injection	
0	0	35.47	35.77	36.27	35.83
	5	35.73	36.73	37.57	36.68
	10	35.97	37.73	38.80	37.50
0.75	0	36.47	38.67	40.07	38.40
	5	36.87	42.50	46.90	42.09
	10	38.57	45.50	50.47	44.84
1.5	0	39.40	50.10	54.73	48.08
	5	40.17	56.40	58.27	51.61
	10	44.80	57.67	60.87	54.44
LSD*0.05*		1.287			0.734
Nano Iron * Biofertilizer					
0		35.72	36.74	37.54	36.67
0.75		37.30	42.22	45.81	41.78
1.5		41.46	54.72	57.96	51.38
LSD*0.05*		0.734			0.429
Chelating Iron * Biofertilizer					
0		37.11	41.51	43.69	40.77
5		37.59	45.21	47.58	43.46
10		39.78	46.97	50.04	45.60
LSD*0.05*		0.734			0.429
Average		38.16	44.56	47.10	
LSD*0.05*		0.429			

chelated iron (N2F2) gave the highest average of (15.66 mg. Kg^{-1}) compared to the treatment (N0F0) which gave the lowest average (10.67 mg. kg^{-1}), and the treatment affected (N2B3) was significant, as it recorded the highest value (16.80 mg. Kg-1) compared to the treatment (N0B1) which gave the lowest value (10.64 mg. kg^{-1}), while the treatment (F2B3) showed a significant superiority and recorded the highest value (14.69 mg. Kg^{-1}) compared to (F0B1) which recorded the lowest value (11.13 mg.kg^{-1}). The treatment of triple interaction between nano iron , chelated iron and bio-fertilizer (B3N2F2) recorded the highest value (17.57 mg. kg^{-1}) compared to treatment (B1N0F0) which recorded the lowest value (10.53 mg.kg^{-1}).

3.2. DISCUSSION

The results presented in the tables (2, 3, 4, 5, 6, 7)showed that spraying with nanoiron gave a significant increase in the elements content in the leaves (nitrogen percentage, phosphorus percentage, potassium percentage) (iron content, manganese content and Zinc content) This may be due to the ability of the Nano fertilizers to provide a larger surface area for different metabolic reactions in Plant, which increases the photosynthesis rate , as iron targets the cell wall and increases the effectiveness of biochemical conversion processes [11]which facilitates the permeability of nutrients into the shoot and root system of the plant and this contributes to increasing Cell divisions, or perhaps because of the effect of spraying low concentrations of nanoscale iron in producing a strong root group with high efficiency in absorbing nutrients from the soil. This result is consistent with [20] ,[21] , [22] in their study on *lettuca sativa* and

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Moringa peregrina, respectively, as they proved that Increasing the concentrations of nanoscale iron increases the concentration of nutrients.

It is clear through the same tables that spraying with chelated iron led to a significant increase of the elements concentration in the leaves, and the reason for this increase may be because of the increase in the amount of iron added in the spray solution and then the increase in the amount absorbed from it by the plant. It stays in the leaves without movement or slow movement, even to the new leaves after the old leaves have fallen, which causes forming the continuation of extending and equipping the plants with more iron. This result consistent with [23] ,[24] ,[25].

The results of the study showed that the addition of the bio- fertilizer gave a significant increase in the above traits. This may be because the microbial interference in the rhizosphere led to important role in increasing the readiness and movement of nutrients dissolving and then their absorption by the plant [26] As it is that beneficial microorganisms can stimulate enzymes such as protease, phosphatase [27] which increases the readiness of the elements because of the mineralization process and prevents their fixation through the formation of complexes with it [28] and Bio fertilizer formulation contained natural chelating compounds that may have contributed to increasing the readiness of mineral elements [29] The humic acid released from Bio fertilizer may have increased the permeability of living cell membranes in the roots, which improved their absorption of the elements and thus increased their content is in the plant .

4.CONCLUSIONS

1- The addition of iron nan fertilizer led to a significant increase in the concentration of nutrients in the leaves, and that the concentration (1.5 g N. L^{-1}) achieved the highest results.

2- The treatment of spraying with chelated iron with a concentration (10g Fe. L^{-1}) achieved a significant increase in the nutrient concentration in the leaves.

3- The integrated fertilization increased the concentration of macro and micronutrients in the leaves.

4- The results showed that the double and triple interactions were significant in all traits of chili plants, as the treatment N_2F_2 gave the highest value compared to the treatment N_0F_0, and the treatment N_2B_3 gave the highest value compared to the treatment, N_0B_1, while the treatment F_2B_3 gave the highest value compared to the treatment F_0B_1. Treatment $N_2F_2B_3$ significantly outperformed and gave the highest value compared to treatment $N_0F_0B_1$.

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