Effect of organic fertilizer and ground feeding with chelated iron & zinc on the concentration of elements in potato(*Solanum tuberosum* L) tubers in soil with low gypsum content

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Abstract
A field experiment was conducted at research station of soil Department and Water Resources, College of Agriculture, University of Tikrit, for agricultural season 2022 AD, according to the randomized complete block design (RCBD), with eighteen treatments and three replications for the purpose of studying the effect of adding organic fertilizer and ground feeding with iron and chelated zinc on the concentration of elements in potato tubers in low soil. Gypsum content, the experiment included three factors each of organic fertilizer at level of (0, 1)% coded as M_0 and M_1, respectively. Chelated iron with three levels (0,2,4) kg ha^{-1} soil, coded as F_0, F_1, and F_2, respectively, and chelated zinc with three levels (0,1.5,3) kg ha^{-1} soil, coded as Z_0, Z_1, and Z_2, respectively. The results showed that adding organic fertilizer, iron and chelated zinc separately led to a significant increase in the studied traits (concentration of nitrogen, phosphorus, potassium, iron and zinc in the tubers). The interaction between organic fertilizer, iron and chelated zinc resulted in a significant increase, as the triple interaction treatment $M_1F_2Z_2$ excelled as it gave the highest values (2.00%, 0.339%, 2.51%, 78.18 mg kg^{-1} and 38.11 mg kg^{-1}) for the above studied traits, respectively, compared to comparison treatment $M_0F_0Z_0$.

Keywords: Gypsum soil, organic fertilizer, chelated iron. Chelated zinc

Introduction

Gypsum soil is defined as a soil containing sufficient quantities of gypsum to be incompatible with plant growth and affect it (FAO, 1990). It was defined by Ismail (1994) as every soil containing gypsum mineral by (3%) or more. Gypsum soils suffer from many problems as a result of the presence of gypsum in them, as there are factors that limit production in these soils, including those related to their physical, chemical and fertility properties, and others related to soil and water management. Gypsum affects the ionic balance of nutrients in soil solution resulting from saturation of its solution. With calcium and sulfate ions, when irrigating crops grown in such soils, the gypsum partially dissolves and forms a solid layer that hinders the growth of plants and the spread of their roots deep into the soil (Van Alphen and Romero, 1971). In addition to its low content of organic matter and clay (Salim, 2001). Organic fertilization is the cornerstone that must be laid to increase soil fertility and reduce environmental pollution resulting from the excessive use of chemical fertilizers, as well as its positive impact on many different soil properties, which is reflected in the activities of the ecosystem in a large way. Organic soil matter constitutes a storehouse of vital energy and a source of macronutrients And stimulate the activity of a number of enzymes and microorganisms (Al-Kalabi, 2018). importance of micronutrients is not less than importance of macronutrients, except in the quantity needed by the plant, and it is less than the macronutrients, and its concentration is about 1-200 mg L^{-1} in the dry plant matter. Its importance is due to its important relationship with various vital interactions, which are due to its direct and indirect effects in activating various enzymes. Iron regulates transpiration in plants by controlling many enzymes (Kumar et al., 2014). In addition, the

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chloroplast organelles are the most absorbent of iron in most types of plant cells, and this shows its importance in the process of carbon metabolism (Divol et al., 2013). As for zinc, it contributes to plant nutrition through its role in the formation of cell growth hormones, acts as an activator of enzymes in the plant, maintains the protein and carbohydrate composition It is related to formation of RNA and plays a synthetic role in the enzymes involved in DNA replication (Al-Shater and Al-Balkhi, 2014). Potato (*Solanum tuberosum* L.) is a tuberous crop belonging to the Solanacea family that ranks fourth as a strategic and economic crop after wheat, corn and rice in Iraq and the world in terms of importance and cultivated area (Shayaa and Hussein, 2019). The potato crop is a food source rich in energy and an important source of many nutritional components, as it contains a high percentage of starches, sugars, proteins, amino acids, mineral elements, and fiber (Alaee, 2018). This study aims to know the effect of adding organic fertilizer and ground feeding with iron and chelated zinc on the concentration of elements in potato tubers.

MATERIALS AND METHODS

A field experiment was carried out according to the randomized complete block design (RCBD) at the research station of Department of Soil sience and Water Resources, College of Agriculture, University of Tikrit, for agricultural season 2022 AD, in soil with a low gypsum content of 5.81%. Soil samples were taken from field before planting from different locations at a depth of (0-30). cm by means of an auger, then mixed well to homogenize it, air dried, smoothed and passed through a sieve with a diameter of 2 mm, a composite sample was taken from it for the purpose of conducting some physical and chemical analyzes of the soil before planting, as shown in Table (1) organic fertilizer analyzed as shown in Table (2), according to the methods mentioned for soil and fertilizer analyzes in (Black، 1965),(Savant,1994) , (page et al,1982),(jackson ,1958), (USDA, Handbook60,1954),(Bermner and Mulvaney,1982),(Soltanpour and Schwab.1977) soil was prepared for cultivation by carrying out the necessary plowing, smoothing and leveling operations. The land was divided into three sectors, each sector was divided into 18 experimental units and each experimental unit into two terraces, each terrace with a length of (2.4) m a width of (0.8) m, and the distance between one terrace and another was (0.75) m. The experimental unit is 8.04 square meters, with a distance of (1) meter separating between the experimental units and sectors for the purpose of preventing transfer of fertilizers between experimental treatments. experiment included (18) experimental units with three replications that were distributed randomly to experimental units within each sector after marking them in each repetition. number of experimental units reached (54) experimental units resulting from (2×3×3×3=54).

The experiment included three factors and they were as follows:

1- Organic fertilization (sheep waste) at two levels (0 and 1%), symbolized M_0 and M_1, respectively.

2- Fertilization with chelated iron Fe-EDDHA at three levels (0, 2, 4) kg ha^{-1}, symbolized F_0, F_1, and F_2, respectively. It contains 6% iron.

3- Fertilization with chelated zinc Zn-EDTA at three levels (0,1.5,3) kg ha^{-1}, symbolized Z_0, Z_1, and Z_2, respectively. It contains zinc by 19%.

Urea fertilizer used (46% N) as a source of nitrogen in two batches at a rate of (200) kg N ha^{-1} , triple superphosphate (21% P) as a source of phosphorus at a rate of one batch before planting at a rate of (120) kg P ha^{-1}, and potassium sulfate (43% k) as asource of potassium in three batches, at a rate of (165) kg K ha^{-1}. Organic fertilizer was added two months before planting, according to the quantity allocated to each experimental unit,. Chelated iron and zinc were added after 45 days of planting, in four batches every two weeks, according to the recommendations of the producing company. Potato tubers (*Solanum tuberosum* L.) Sefra variety were planted 12/2/2022 inside a deep incision (0.1-0.12 m) and then covered tubers with soil, distance between one tuber and another was 0.4 m, and a distance of 0.2 m was left at the

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beginning and end of each line, number of tubers in experimental unit was 12 tubers, for pass seed 6 tubers. drip irrigation was used, The process of covering the terraces with polyethlene (Malch) was carried out to get rid of weeds and herbs and to facilitate service operations related to crop according to the recommendations used in potato cultivation and for all experimental units in a similar way and whenever needed until the completion of all stages of plant growth. With potato cultivation, potato tubers were dipped in a systemic fungicide Topsin (wp) to prevent diseases, and on 16/4/2022, preventive spraying was carried out with insecticide Dominant to prevent biting insects for all experimental units equally, as well as preventive and curative spraying with coppermac fungicide To avoid infection with early and late blight, spraying was repeated on 1/5/2022 with insecticide and fungicide.

Table (1) Some physical and chemical properties of field soil before planting

adjectives	Measuring unit	The value
Sand	gm kg^{-1}	440
Silt		325
Clay		235
Texture		L
CEC	Santi mole $.kg^{-1}$	14.24
PH 1:1		7.49
Ec 1:1	Desi simmens . m^{-1}	2.36
$CaSO_4.2H_2O$	%	5.81
$CaCO_3$	gm kg^{-1}	263
O.M		8.02
available Nitrogen	mg $.kg^{-1}$	18.95
available phosphorous		6.11
available potassium		134.00
available zinc		0.516
available iron		1.091
Na^+	Mmol $.liter^{-1}$	1.11
K^+		0.85
Ca^+		6.40
Mg^+		4.22
Cl^-		3.02
CO_3^-		nill
HCO_3^-		1.26
SO_4^-		9.48

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Table (2) Analysis of organic fertilizer

Adjective	The value
PH 5:1	7.47
EC 5:1	8.32 dsiemens.m^{-1}
Total nitrogen	3.17%
Total phosphorus	0.595%
Total potassium	0.86%
Organic carbon	45.20%
C:N Ratio	14.25

Studied traits

Elemental analyzes in tubers

After takeoff the tubers, five homogeneous tubers were taken for each experimental unit, washed with tap water, then with distilled water, cut into slices, and dried in the oven at a temperature of (65-70) C until the weight was stable. 1:2) according to the method proposed by (Gresser and Parson, 1979), then the samples were transferred quantitatively into volumetric bottles of (50) ml capacity, and the volume was filled with distilled water, and the following estimates were made:

Nitrogen estimation: Determination of nitrogen in the digested plant extract using a microckeldal according to the method proposed by Bremner and Mulvany (1982).

Phosphorous Estimation: Total phosphorus was determined in the digested plant extract using a spectrophotometer, at a wavelength of 884 nanometers, according to the method (Olsen et al., 1954).

Potassium estimate: It was estimated in the digested plant extract using a flame photometer as indicated by Haynes (1980).

Determination of iron and zinc: They were estimated using the atomic absorption apparatus as stated in Haynes (1980).

Results and discussion

Tuber nitrogen concentration (%)

The results of Table (3) showed that the addition of organic fertilizer led to a significant increase in the concentration of nitrogen in the tubers of the potato plant, as raising the level of fertilizer from M_0 to M_1 led to a significant increase in the nitrogen concentration of potato tubers amounted to (1.53,1.83)%, respectively, with an increase rate amounted to 19.61% The reason for this may be due to the role of organic fertilizer in improving the fertility characteristics of the soil and the nutrients its contains from nutrients that are avialable for absorption, including the nitrogen element, as well as that it works to increase the concentration of nitrogen in the soil through its decomposition and the release of nitrogen liberated from it and its conversion from the organic form to the mineral form by the process of mineralization as a result For the activities of microorganisms, in addition to that the organic fertilizer increases the enzymatic and biological activity in the plant, and this increased the efficiency of the plant to absorb nitrogen (Devi and Khwairakpam, 2020), which was reflected in an increase in its concentration in the tubers. These results are consistent with the results of Biruk-Masrie et al. (2014) whose found that The addition of organic fertilizer led to a significant increase in the nitrogen concentration in potato tubers.

The results of Table (3) show that the addition of chelated iron led to a significant increase in the concentration of nitrogen in the

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tubers of potato plant in two locations, as raising fertilizer level from F_0 to F_2 led to a significant increase in the nitrogen concentration of potato tubers amounted to (1.70, 1.78)%, with an increase of 8.28% and 13.37% for levels F_1 and F_2, respectively, compared to level F_0, which amounted to (1.57%). The reason for the increase in nitrogen concentration in tubers may be due to the role of iron in activating many vital processes such as respiration, carbon metabolism chlorophyll, and then increasing energy and vegetative growth, which is reflected in plant growth and increased absorption of nutrients, and by providing a carrier factor that leads to transferring them to tubers and then increasing their concentration in tubers These results are in line with the results of Al-Dulaimi (2020), who found that the addition of iron led to a significant increase in the nitrogen concentration in potato tubers.

Table (3) Effect of adding organic fertilizer and ground feeding with chelated iron and zinc and the interaction between them on nitrogen concentration (%) in potato tubers in soil with low gypsum content

Level of organic fertilization(m)	Chelated iron levels Kg E^{-1} (F)	Added zinc levels Kg E^{-1} (Z)			Average overlap MxF
		Z_0	Z_1	Z_2	
M_0	F_0	1.39 q	1.44 p	1.48 o	1.44 f
	F_1	1.47 o	1.55 n	1.60 l	1.54 e
	F_2	1.57 m	1.62 k	1.68 i	1.62 d
M_1	F_0	1.65 j	1.71 h	1.75 g	1.70 c
	F_1	1.81 f	1.88 d	1.90 c	1.86 b
	F_2	1.86 e	1.96 b	2.00 a	1.94 a
					average F
average overlap FxZ	F_0	1.52 h	1.57 g	1.61 f	1.57 c
	F_1	1.64 e	1.71 d	1.75 c	1.70 b
	F_2	1.71 d	1.79 b	1.84 a	1.78 a
					average M
average overlap MxZ	M_0	1.48 f	1.54 e	1.59 d	1.53 b
	M1	1.77 c	1.85 b	1.88 a	1.83 a
average Z		1.62 c	1.69 b	1.73 a	
M_0 ; without adding organic fertilizer. $M_{1;}$ adding organic fertilizer with an average of (1) %		F0 ; (0) kg e-1 f1 ; (2) kg f h-1 f2 ; (4) kg f h-1		Z_0 ; (0) kg zn e^{-1} Z_1 ; (1.5) kg zn h^{-1} Z_2 ; (3) kg zn h^{-1}	
Averages with similar letters, there are no significant differences between them according to the Duncan test at the level of probability 5 %					

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The addition of chelated zinc led to a significant increase in concentration of nitrogen in the tubers of potato plant, as raising fertilizer level from Z_0 to Z_2 led to a significant increase in nitrogen concentration of the potato tubers amounted to (1.69, 1.73)%, with an increase of 4.32% and 6.79% for levels Z_1 and Z_2. Respectively, compared to the Z_0 level, which amounted to (1.62)%. The reason for the increase in nitrogen concentration in the tubers may be due to the role of zinc in the formation of amino acids, carbohydrates, energy compounds, and formation neuclicaeid of (RNA), as well as its important role in activating many enzymes and increasing the processes of respiration and carbon metabolism, which increases the activity of the plant in absorption of water and nutrients, including nitrogen, these results are consistent with The results of Al-Falahi (2021) found that the addition of chelated zinc led to a significant increase in the nitrogen concentration in potato tubers.

The bilateral interaction between organic fertilizer and chelated iron led to a significant increase in the nitrogen concentration in potato plant tubers, as treatment M_1F_2 gave the highest average of (1.94)%, while treatment M_0F_0 gave the lowest average amounted to (1.44)%, with an increase of 34.72%.

The bilateral interaction between organic fertilizer and chelated zinc led to a significant increase in the nitrogen concentration in the tubers of the potato plant, as the treatment M_1Z_2 gave the highest average of (1.88)%, while the treatment M_0Z_0 gave the lowest average amounted to (1.48)%, with an increase of 27.03%.

The dual interaction between iron and chelated zinc led to a significant increase in the concentration of nitrogen in the tubers of the potato plant, as the treatment F_2Z_2 gave the highest average of (1.84)%, which was significantly superior to all treatments in this overlap, while the treatment F_0Z_0 gave the lowest average of (1.52)% by An increase of 21.05%.

The triple interaction between organic fertilizer, chelated iron and zinc led to an increase in the nitrogen concentration in potato plant tubers, as the treatment $M_1F_2Z_2$ gave the highest average of (2.00)%, which was significantly superior to all treatments in this interaction, while the comparison treatment $M_0F_0Z_0$ gave the lowest average of (1.39). %, an increase of 43.88%.

Concentration of phosphorus in tubers (%)

The results of Table (4) showed that the addition of organic fertilizer led to a significant increase in the concentration of phosphorus in tubers of potato plant, as raising the level of fertilizer from M_0 to M_1 led to a significant increase in the concentration of phosphorous for tubers, which amounted to (0.257, 0.297)%, respectively, with an increase of 15.56% this may be due to the role of organic fertilizer in holding and chelating positive ions in the soil, which leads to a reduction or inhibition of the adsorption and precipitation reactions of phosphorus in the soil and its work as a chelating substance that limits the loss of elements and their precipitation from the soil as well as its role in reducing the degree of soil interaction in the root zone through Its release of hydrogen ions, various organic acids, and CO_2 gas when it decomposes and forms carbonic acid, which works to dissolve complex and insoluble phosphorus compounds, which leads to an increase in the values of ready phosphorus in the soil, and then this was reflected in an increase in the concentration of phosphorus in the tubers of the potato plant. These results are consistent with the results of Bashir and Qureshi (2014).

The results of Table (4) showed that the addition of chelated iron led to a significant increase in the concentration of phosphorus in tubers of potato plant as raising the fertilizer level from F_0 to F_2 led to a significant increase in the concentration of phosphorus in the tubers reached (0.276, 0.304)%, with an increase of 9.96% and 21.11% for F_1 and F_2 levels, respectively, compared to F_0 level, which amounted to (0.251)%. This may be due to the role of iron in increasing the efficiency of the carbon metabolism process and building chlorophyll, as well as its role in building ferredoxin, which carries the electron in the carbon metabolism process, and leads to an

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increase in the rate of formation of carbohydrates that are transported by the descending sap to the absorption sites in the roots, as well as the fact that the carbohydrates It is an important source of bio-absorption energy of phosphorus through the roots, which was reflected in increase in concentration of phosphorus in the tubers. These results are consistent with the results of Mahmoud et al. (2013) who found that the addition of chelated iron led to a significant increase in the concentration of phosphorus in tubers of potato plant.

Table (4) Effect of adding organic fertilizer and ground feeding with chelated iron and zinc and the interaction between them on the phosphorus concentration (%) in potato tubers in soil with low gypsum content

Level of organic fertilization(m)	**Chelated iron levels Kg E^{-1} (F)**	**Added zinc levels Kg E^{-1} (Z)**			**Average overlap MxF**
		Z_0	**Z_1**	**Z_2**	
M_0	**F_0**	0.225 o	0.241 m	0.253 l	0.240 f
	F_1	0.233 n	0.259 k	0.267 j	0.253 e
	F_2	0.271 i	0.282 gh	0.284 fg	0.279 c
M_1	**F_0**	0.239 m	0.266 j	0.280 h	0.262 d
	F_1	0.285 f	0.301 e	0.314 d	0.300 b
	F_2	0.320 c	0.331 b	0.339 a	0.330 a
					average F
average overlap FxZ	**F_0**	0.232 i	0.253 h	0.266 f	0.251 c
	F_1	0.259 g	0.280 e	0.290 d	0.276 b
	F_2	0.295 c	0.306 b	0.311 a	0.304 a
					average M
average overlap MxZ	**M_0**	0.243 f	0.261 e	0.268 d	0.257 b
	M1	0.281 c	0.299 b	0.311 a	0.297 a
average Z		0.262 c	0.280 b	0.289 a	
M_0 ; without adding organic fertilizer. $M_{1;}$ adding organic fertilizer with an average of (1) %		F0 ; (0) kg e-1 f1 ; (2) kg f h-1 f2 ; (4) kg f h-1		Z_0 ; (0) kg zn e^{-1} Z_1 ; (1.5) kg zn h^{-1} Z_2 ; (3) kg zn h^{-1}	
Averages with similar letters, there are no significant differences between them according to the Duncan test at the level of probability 5 %					

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The addition of chelated zinc led to a significant increase in the concentration of phosphorus in the tubers of potato plant, as raising the level of fertilizer from Z_0 to Z_2 led to a significant increase in the concentration of phosphorous for tubers of (0.280, 0.289)%, with an increase of 6.87% and 10.30% for levels Z_1 and Z_2 over Ranking compared to level Z_0, which amounted to (0.262)% this may be due to the role of zinc, as essential element in the formation of the amino acid tryptophan, of which auxin is formed, which is responsible for increasing root growth and increasing the absorption of nutrients from the soil, including phosphorus, which plays an important role in plant cell division as well as its direct role in energy generation. And it is included in the composition of enzymes, in addition to that good nutrition of zinc increases plant growth and increases its ability to absorb many elements, including phosphorus, and these results are in line with the results of Al-Falahi (2021).

The bilateral interaction between organic fertilizer and chelated iron led to a significant increase in concentration of phosphorus in potato tubers, as treatment M_1F_2 gave the highest average of (0.330)%, while treatment M_0F_0 gave the lowest average amounted to (0.240)%, with an increase of 37.50%.

The bilateral interaction between the organic fertilizer and chelated zinc led to a significant increase in the concentration of phosphorus in tubers of potato plant, as the treatment M_1Z_2 gave the highest average of (0.311)%, while the treatment M_0Z_0 gave the lowest average amounted to (0.243)%, with an increase of 27.98.

The bilateral interaction between iron and chelated zinc led to a significant increase in the concentration of phosphorus in the tubers of potato plant, as the treatment F_2Z_2 gave the highest average of (0.311)%, which was significantly superior to all treatments in this overlap, while the treatment F_0Z_0 gave the lowest average of (0.232)% by An increase of 34.05%.

The triple interaction between organic fertilizer, iron and chelated zinc led to an increase in the concentration of phosphorus in the tubers of potato plant, as the treatment $M_1F_2Z_2$ gave the highest average of (0.339)%, which was significantly superior to all treatments in this overlap, while the comparison treatment $M_0F_0Z_0$ gave the lowest average of (0.225). %, an increase of 50.67%.

Potassium concentration in tubers (%)

The results of Table (5) showed that the addition of organic fertilizer led to a significant increase in the concentration of potassium in the tubers of potato plant, as raising the fertilizer level from M_0 to M_1 led to a significant increase in the potassium concentration of the tubers, which amounted to (2.02, 2.22)%, respectively, with an increase amounting to 9.90% this may be due to the role of organic fertilizer in improving the physical and chemical properties of the soil and providing ideal conditions for the growth of root system, which increases the absorption of water and nutrients, in addition to the fact that organic fertilizer, after its decomposition, produces a group of humic and organic acids that help in dissolving nutrients, including potassium, in order to It be avialabe for uptake by plant roots (Sarwar et al., 2012), these results are consistent with results of Ahmed et al. (2015) who found that the addition of organic fertilizer led to a significant increase in potassium concentration in potato tubers.

The results of Table (5) showed that addition of chelated iron led to a significant increase in potassium concentration in tubers of potato plant, as raising the fertilizer level from F_0 to F_2 led to a significant increase in potassium concentration of the tubers. It reached (2.11, 2.26)%, with an increase of 6.56% and 14.14% for levels F_1 and F_2, respectively, compared to level F_0, which amounted to (1.98%). This may be due to the role of iron in encouraging the absorption of potassium from the soil because it works to increase the efficiency of the carbon metabolism process, as well as plays a role in the formation of chlorophyll and activates many enzymes, which leads to an increase in the efficiency of the plant in absorbing nutrients from the soil, including potassium The results are consistent with the results of Al-Halbousi (2017), who

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found that the addition of chelated iron led to a significant increase in potassium concentration in potato tube

Table (5) Effect of adding organic fertilizer and ground feeding with chelated iron and zinc and the interaction between them on potassium concentration (%) in potato tubers in soil with low gypsum content

Level of organic fertilization(m)	Chelated iron levels Kg E^{-1} (F)	Added zinc levels Kg E^{-1} (Z)			Average overlap MxF
		Z_0	Z_1	Z_2	
M_0	F_0	1.83 q	1.92 o	1.99 l	1.91 f
	F_1	1.89 p	2.05 j	2.11 h	2.02 e
	F_2	1.97 m	2.18 f	2.24 e	2.13 c
M_1	F_0	1.95 n	2.09 i	2.15 g	2.06 d
	F_1	2.04 k	2.27 d	2.33 c	2.21 b
	F_2	2.19 f	2.47 b	2.51 a	2.39 a
					average F
average overlap FxZ	F_0	1.89 i	2.00 g	2.07 f	1.98 c
	F_1	1.96 h	2.16 d	2.22 c	2.11 b
	F_2	2.08 e	2.32 b	2.37 a	2.26 a
					average M
average overlap MxZ	M_0	1.90 f	2.05 e	2.11 c	2.02 b
	M1	2.06 d	2.28 b	2.33 a	2.22 a
average Z		1.98 c	2.16 b	2.22 a	
M_0 ; without adding organic fertilizer. M_1; adding organic fertilizer with an average of (1) %		F0 ; (0) kg e-1 f1 ; (2) kg f h-1 f2 ; (4) kg f h-1		Z_0 ; (0) kg zn e^{-1} Z_1 ; (1.5) kg zn h^{-1} Z_2 ; (3) kg zn h^{-1}	
Averages with similar letters, there are no significant differences between them according to the Duncan test at the level of probability 5 %					

The addition of chelated zinc led to a significant increase in the concentration of potassium in the tubers of potato plant, as raising the fertilizer level from Z_0 to Z_2 led to a significant increase in potassium concentration of the tubers amounting to

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(2.16, 2.22)%, with an increase rate of 9.09% and 12.12% for levels Z_1 and Z_2 over The ranking compared to the Z_0 level, which amounted to (1.98)%. This may be due to the important role of zinc in formation of amino acid tryptophan, from which the hormone (IAA) is known to increase growth, as well as its role in formation of chlorophyll, amino acids and carbohydrates, and the increase in the ability of the plant to obtain an adequate amount of nutrients, which is reflected in this It positively affects the better growth of a strong root system and the ability of roots to absorb nutrients from the soil, these results are in line with the results of Mahmoud et al. (2013).

The bilateral interaction between organic fertilizer and chelated iron led to a significant increase in the concentration of potassium in the tubers of potato plant as the treatment M_1F_2 gave the highest average of (2.39)%, while the treatment M_0F_0 gave the lowest average amounted to (1.91)%, with an increase of 25.13%. .

The bilateral interaction between organic fertilizer and chelated zinc led to a significant increase in potassium concentration in potato plant tubers, as the treatment M_1Z_2 gave the highest average of (2.33)%, while the treatment M_0Z_0 gave the lowest average of (1.90)%, with an increase of 22.63%.

The bilateral interaction between iron and chelated zinc led to a significant increase in the concentration of potassium in potato plant tubers, as the treatment F_2Z_2 gave the highest average of (2.37)%, which was significantly superior to all treatments in this overlap, while the treatment F_0Z_0 gave the lowest average of (1.89)% by An increase of 25.39%.

The triple interaction between organic fertilizer, iron and chelated zinc led to an increase in the concentration of potassium in potato plant tubers, as the treatment $M_1F_2Z_2$ gave the highest average of (2.51)%, which was significantly superior to all treatments in this interaction, while the comparison treatment $M_0F_0Z_0$ gave the lowest average of (1.83). %, an increase of 37.16%.

Iron concentration in tubers (mg kg^{-1})

The results of Table (6) showed that the addition of organic fertilizer led to a significant increase in the concentration of iron in tubers of potato plant as raising the fertilizer level from M_0 to M_1 There was a significant increase in the iron concentration of the tubers, which amounted to (52.92, 61.24) mg kg^{-1}, respectively, with an increase rate of 15.72%. this may be attributed to the role of organic fertilizer in improving physical and chemical properties of soil and fertility, which helped to increase the availability of iron in soil solution and made it available for absorption by root system as well as its role in increasing availability of nutrients, which helped the roots to grow better and form Effective root system strong and efficient in absorbing nutrients and then reflected positively on plant growth as well as the role of organic fertilizer in maintaining soil moisture and increasing the availability of nutrients and preventing their fixation by forming complexes compounds with them, which was reflected in an increase in the concentration of iron in potato tubers. These results are consistent with the results of Al-Dulaimi (2020).

The results of Table (6) showed that the addition of chelated iron led to a significant increase in the concentration of iron in the tubers of potato plant, as raising the level of fertilizer from F_0 to F_2 led to a significant increase in the concentration of iron in tubers reached (59.97, 69.20) mg kg^{-1}, with an increase of 42.51% and 64.45% for levels F_1 and F_2, respectively, compared to level F_0, which amounted to (42.08) mg kg^{-1}. this may be attributed to the role of iron in the formation of a deep and large root system, which led to an increase in root secretions and then an increase in the absorption of nutrients, as well as the role of iron in increasing chlorophyll content of leaves, which led to an increase in the process of carbon metabolism, improved vegetative growth and an increase in size of root system. Which was reflected in an increase in efficiency of iron absorption in the tubers, these results are consistent with the results of Gugała et al. (2018).

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Table (6) Effect of adding organic fertilizer and ground feeding with chelated iron and zinc and the interaction between them on the concentration of iron (mg kg^{-1}) in potato tubers in soil with low gypsum

Level of organic fertilization(m)	Chelated iron levels Kg E^{-1} (F)	Added zinc levels Kg E^{-1} (Z)			Average overlap MxF
		Z_0	Z_1	Z_2	
M_0	F_0	39.12 r	42.00 p	42.24 o	41.12 f
	F_1	52.70 l	54.89 k	56.09 J	54.56 d
	F_2	61.16 I	63.94 g	64.19 F	63.10 c
M_1	F_0	40.97 q	43.11 n	45.03 m	43.04 e
	F_1	62.33 h	65.67 e	68.14 d	65.38 b
	F_2	72.62 c	75.09 b	78.18 a	75.30 a
					average F
average overlap FxZ	F_0	40.04 I	42.55 h	43.63 g	42.08 c
	F_1	57.51 f	60.28 e	62.11 d	59.97 b
	F_2	66.89 c	69.51 b	71.19 a	69.20 a
					average M
average overlap MxZ	M_0	50.99 f	53.61 e	54.17 d	52.92 b
	M1	58.64 c	61.29 b	63.78 a	61.24 a
average Z		54.82 c	57.45 b	58.97 a	
M_0 ; without adding organic fertilizer. $M_{1;}$ adding organic fertilizer with an average of (1) %		F0 ; (0) kg e-1 f1 ; (2) kg f h-1 f2 ; (4) kg f h-1		Z_0 ; (0) kg zn e^{-1} Z_1 ; (1.5) kg zn h^{-1} Z_2 ; (3) kg zn h^{-1}	
Averages with similar letters, there are no significant differences between them according to the Duncan test at the level of probability 5 %					

The addition of chelated zinc led to a significant increase in concentration of iron in tubers of potato plant, as raising the level of fertilizer from Z_0 to Z_2 led to a significant increase in the concentration of iron in tubers, which amounted to (57.45, 58.97) mg kg^{-1}, with an increase of 4.80% and 7.57% for the levels Z_1 and Z_2, respectively, compared to Z_0 level, which amounted to (54.82) mg kg^{-1} this may be attributed to the role of zinc in building proteins, DNA and RNA, and contributing to their regulation, as well as its important role in many different enzymes and ribosomes, as well as its role in formation or construction of carbohydrates, chlorophyll and root growth, which greatly enhances the

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absorption of nutrients and increases their content in the plant, which It was reflected in an increase in the concentration of iron in the tubers, and these results are consistent with the results of Al-Falahi (2021), who indicated that the addition of chelated zinc led to an increase in the concentration of iron in the tubers of the potato plant.

The bilateral interaction between organic fertilizer and chelated iron led to a significant increase in concentration of iron in potato plant tubers, as treatment M_1F_2 gave the highest average of (75.30) mg kg^{-1}, while treatment M_0F_0 gave the lowest average amounted to (41.12) mg kg^{-1} with a ratio of An increase of 83.12%.

The bilateral interaction between organic fertilizer and chelated zinc led to a significant increase in the concentration of iron in the tubers of potato plant, as the treatment M_1Z_2 gave the highest average of (63.78) mg kg^{-1}, while the treatment M_0 Z_0 gave the lowest average amounted to (50.99) mg kg^{-1} with an increase percentage amounted to 25.08%.

The dual interaction between iron and chelated zinc led to a significant increase in the concentration of iron in potato plant tubers, as the treatment F_2Z_2 gave the highest average of (71.19) mg kg^{-1}, which was significantly superior to all treatments in this interaction, while the treatment F_0Z_0 gave the lowest average of (40.04).) mg kg^{-1} with an increase rate of 77.79%.

The triple interaction between organic fertilizer, iron and chelated zinc led to an increase in the concentration of iron in potato plant tubers, as the treatment $M_1F_2Z_2$ gave the highest average of (78.18) mg kg^{-1}, which was significantly superior to all treatments in this overlap, while the comparison treatment $M_0F_0Z_0$ gave the lowest average (39.12) mg kg^{-1}, an increase of 99.85%.

Zinc concentration in tubers (mg kg^{-1})

The results of Table (7) showed that addition of organic fertilizer led to a significant increase in zinc concentration in tubers of potato plant, as raising the fertilizer level from M_0 to M_1 There was a significant increase in zinc concentration in tubers, which amounted to (28.48, 30.70) mg kg^{-1}, respectively, with an increase rate of 7.79%. this may be attributed to the role of organic fertilizer in improving chemical and physical properties of soil, and that the organic fertilizer raises the temperature of the root zone, which increases its respiration, thus increasing the growth of the root system and increasing its absorption of nutrients, as well as the addition of organic fertilizer to the soil, which causes an increase in the activity and number of microorganisms, and this increases The availability of nutrients, and absorption by plant, which was reflected in an increase in the concentration of zinc in the tubers. These results are consistent with the results of Youdeh (2018) and Al-Yasari (2019), who found that the addition of organic fertilizer led to an increase in the concentration of zinc in the tubers of the potato plant.

The results of Table (7) showed that the addition of chelated iron led to a significant increase in the concentration of zinc in tubers of potato plant, as raising the fertilizer level from F_0 to F_2 led to a significant increase in the zinc concentration of the tubers amounted to (29.39, 31.70) mg kg^{-1}, with an increase of 6.14% and 14.48% for levels F_1 and F_2, respectively, compared to level F_0, which amounted to (27.69) mg kg^{-1}. this may be attributed to the important role of iron in formation of cytochromes and ferredoxins , and the increase in the leaf content of chlorophyll, which has a positive effect on the carbon metabolism process, as well as its role in the formation of a deep and large root system, which increases vegetative growth rates and increases the absorption of nutrients, which is reflected in increase zinc concentration. in potato tubers, these results are consistent with the results of Al-Tikriti and Al-Falahi (2021).

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Table (7) Effect of adding organic fertilizer and ground feeding with iron and chelated zinc and the interaction between them on zinc concentration (mg kg^{-1}) in potato tubers in soil with low gypsum content

Level of organic fertilization(m)	**Chelated iron levels Kg E^{-1} (F)**	**Added zinc levels Kg E^{-1} (Z)**			**Average overlap MxF**
		Z_0	**Z_1**	**Z_2**	
M_0	**F_0**	22.50 r	27.23 l	33.03 g	27.58 f
	F_1	22.60 p	28.14 j	33.58 e	28.11 d
	F_2	23.69 o	30.10 i	35.44 d	29.74 c
M_1	**F_0**	22.55 q	27.75 k	33.08 f	27.79 e
	F_1	24.89 n	31.22 h	35.91 c	30.67 b
	F_2	26.03 m	36.81 b	38.11 a	33.65 a
					average F
average overlap FxZ	**F_0**	22.52 i	27.49 f	33.05 d	27.69 c
	F_1	23.74 h	29.68 e	34.74 b	29.39 b
	F_2	24.86 g	33.45 c	36.77 a	31.70 a
					average M
average overlap MxZ	**M_0**	22.93 f	28.49 d	34.01 b	28.48 b
	M1	24.49 e	31.93 c	35.70 a	30.70 a
average Z		23.71 c	30.21 b	34.86 a	
M_0 ; without adding organic fertilizer. M_1; adding organic fertilizer with an average of (1) %		F0 ; (0) kg e-1 f1 ; (2) kg f h-1 f2 ; (4) kg f h-1		Z_0 ; (0) kg zn e^{-1} Z_1 ; (1.5) kg zn h^{-1} Z_2 ; (3) kg zn h^{-1}	
Averages with similar letters, there are no significant differences between them according to the Duncan test at the level of probability 5 %					

The addition of chelated zinc led to a significant increase in the zinc concentration in the tubers of potato plant, as raising the fertilizer level from Z_0 to Z_2 led to a significant increase in the zinc concentration in the tubers, which amounted to (30.21, 34.86) mg kg^{-1}, with an increase of 27.41% and 27.03%. levels Z_1 and Z_2, respectively, compared to the Z_0 level, which amounted to (23.71) mg kg^{-1} this may be attributed to the role of zinc in raising the efficiency of carbon methylation process, increasing the accumulation of synthesized materials in the plant, and increasing plant's ability to absorb

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nutrients, which was reflected in increase the concentration of zinc in tubers. These results are consistent with results of Gurmani et al. (2012) who found an increase in the concentration of zinc in the fruits Tomatoes increase levels of zinc.

The bilateral interaction between organic fertilizer and chelated iron led to a significant increase in zinc concentration in tubers of potato plant, as the treatment M_1F_2 gave the highest average of (33.65) mg kg^{-1}, while the treatment M_0F_0 gave the lowest average amounted to (27.58) mg kg^{-1} with a ratio of An increase of 22.00%.

The bilateral interaction between organic fertilizer and chelated zinc led to a significant increase in the zinc concentration in potato plant tubers, as the treatment M_1Z_2 gave the highest average of (35.70) mg kg^{-1}, while the treatment M_0 Z_0 gave the lowest average amounted to (22.93) mg kg^{-1} with an increase rate reached 55.69%.

The dual interaction between iron and chelated zinc led to a significant increase in concentration of zinc in tubers of potato plant, as the treatment F_2Z_2 gave the highest average of (36.77) mg kg^{-1}, which was significantly superior to all treatments in this interaction, while the treatment F_0Z_0 gave the lowest average of (22.52).) mg kg^{-1} with an increase of 63.28%.

The triple interaction between organic fertilizer, iron and chelated zinc led to an increase in the concentration of zinc in potato plant tubers, as the treatment $M_1F_2Z_2$ gave the highest average of (38.11) mg kg^{-1}, which was significantly superior to all treatments in this overlap, while the comparison treatment $M_0F_0Z_0$ gave the lowest average (22.50) mg kg^{-1}, an increase of 54.98%.

References

Ahmed, A.A. M.F. Zaki, M.R. Shafeek, Y.I. Helmy and M.M.H. Abd El-Baky .. (2015) , Integrated use of Farmyard Manure and Inorganic Nitrogen Fertilizer on Growth, Yield and Quality of Potato (Solanum tuberosum L. , international journal of current microbology and applied sciences , ISSN: 2319-7706 Volume 4 Number 10 pp. 325-349.

Alaee, S. (2018). Air Pollution and Infertility– A letter to Editor. J of Environ Treat Tech, 6(4): 72-3.

Al-Dulaimi, Najah Hamed Obaid. (2020). The effect of fertilization with Conocarpus residues and spraying with iron and boron on the growth and production of potatoes and the storage capacity of tubers (Solanum tuberosum L. PhD thesis, College of Agricultural Engineering Sciences - University of Baghdad.

Al-Falahi, Ahmed Jamal Hindi. (2021). Comparison of foliar feeding and soil applications of chelated microelements on the growth and yield of potatoes in gypsum soil. Master thesis - College of Agriculture - University of Tikrit.

Al-Halbousi, Marwan Mahmoud Hamad. (2017). Effect of cultivar and spraying with humic acid and chelated iron on the growth and yield of potatoes. Master's thesis, College of Agriculture - Anbar University.

Al-Kalabi, Jawad Enad Mahdi. (2018). The role of mycorrhiza and different phosphate sources and compost in the availability of phosphorus and copper in the soil and the growth and yield of maize, PhD thesis, College of Agriculture, University of Baghdad.

Al-Shater, Muhammad Saeed and Akram Al-Balkhi. (2014). Soil fertility and plant nutrition (theoretical part), Damascus University Press.

Al-Tikriti, Iyad Ahmed Hamadeh and Ahmed Jamal Hindi Al-Falahi. (2021). The effect of foliar feeding and ground applications of chelating microelements on the concentration of iron and zinc in leaves and tubers of potato (Solanum tuberosum L.) in gypsum soil. Journal of Basic Education College Research, 17 (2), 1419-1446.

Al-Yasari, Mahmoud Nasser Hussein. (2019). The effect of mineral and organic fertilization and spraying with iron and zinc nanoparticles on the growth and yield of potato, Solanum tuberosum L, PhD thesis. College of Agricultural Engineering Sciences, University of Baghdad.

Bashir, U. and F.Qureshi .(2014).Effect of nitrogen and farmyard manure on yield,

ISSN 2072-3857

nutrient content and quality of potato (solanum tuberosum L.). Biolife J. Vol2,lssue 3 ,792-796.

Biruk-Masrie, Z.; R. Nigussie-Dechassa ; B. Abebie; Y.Alemayehu and T.Tana.(2014).Influence of combined application of in organignandp fertilizers and cattle manure on quality and shelf-life of potato (solanum tuberosum L.) tubers. J.of postharvest technology .2(3):152-168.

Black, C.A. (1965). Methods of Soil analysis part 2. Agronomy 9.SSSA.ASA. Madison, Wisconsin, USA.

Bremner ,J.M .and C.S. Mulvaney. (1982). Total nitrogen. P:595- 624 . In A.L. (ed.) , Methods of soil analysis . Agron . NO:9 Part (2): Chemical and Microbiological properties, 2nd Ed., Am .Soc. Agron.

Devi, C. and M. Khwairakpam .(2020). Bioconversion of Lantana camara by vermicomposting with two different earthworm species in monoculture. Bioresource technology. Journal Pre-Proofs, (296):122308 .

Divol, F. ; Couch, D. ; Conejero, G. ; Roschzttardtz, H. ; Mari, S. and Curie, C. (2013) . The Arabidopsis YELLOW STRIPE LIKE4 and 6 Transporters Control Iron Release from the Chloroplast. The Plant Cell, 25(3): 1040–1055.

FAO, (1990). Management of gypsiferous soils, bulletin, No:62, Food and agriculture organization, Rome, Italy.

Gresser, M.S. and J.W. Parson. (1979). Sulfuric – perchloric acid digestion of plant material of determinations of nitrogen , phosphorus , potassium , calcium and magnesium. Analytical Chemical Acta. 109 : 431-436.

Gugała,M,. Zarzecka,K Mystkowska,I,. and Sikorska,A,. (2018). Iron and manganese content and uptake with the yield of potato tubers as affected by herbicides and biostimulants, and potato tuber nutritional value. Emirates Journal of Food and Agriculture. 30(12): 1051-1057.

Gurmani, A.R., J.U. Din, S.U. Khan, R. Andaleep, K. Waseem, A. Khan, and Hadyatullah. (2012). Soil application of Zinc imporves growth and yield of Tomato. Inter. J. of Agric. And Bio. Vol. 14(1): 91-96.

Haynes, R.J. (1980). A Comparison of two modified kjeldhal digestion techniques for Multi- element plant analysis with conventional wet and dry ashing methods. Communein. Soil. Sci. plant Analysis. 11(5): 459-467.

Ismail, Hamid Nashat. (1994). Exploitation of gypsum soils, proceedings of the symposium on gypsum soils and their impact on facilities, National Center for Structural Laboratories, Baghdad, pp. 52-62.

Jackson, M.L. (1958). Soil chemical analysis. Prentice – Hall. Inc. Engle Wood, Cliffs. N.11:188-196.

Kumar, A. ; Kumar , S. ; Kumar ,P. and Kumar, P.(2014) . Effect of zinc and iron application on yield and acquisition of nutrient on mustard crop (Brassica juncia L.).Journal of Plant Development Sciences ,6 (3) : 413-416.

Mahmoud, Jawad Taha, Hamid Khalaf Al-Salmani, and Muhammad Salal Al-Tamimi. (2013). The effect of spraying with iron and zinc on the concentration of N, P and K elements and the specific characteristics of organically fertilized potatoes. Iraqi Journal of Science and Technology (1) 4.

Olsen, S. R., C. V. Coles, F. S. Watanabe, and L. A. Dean.(1954). Estimation of available phosphorus in soil by extraction with sodium bicarbonate. USDA. 939.

Page, A.I.; R.H. Miller and D.R. Kenney. (1982). Methods of Soil Analysis, Part (2). 2nd ed. Agronomy 9 Am. Soc. Agron. Madison, Wisconsin.

Results and discussion

Salim, Qasim Ahmed. (2001). Effect of irrigation water quality and method of adding it on the properties of gypsum soils in Al-Dur area. PhD dissertation. faculty of Agriculture. Baghdad University.

Sarwar , M .; M. E. Akhtar M. and S. I. Hyder. (2012). Effect of humic acid and phosphorous on yield and nutrient availability in soil and uptake by peas. Prime Journal of Physical Science (PJPS) ,. 1 (5): 53 – 57.

Savant,N.K. .(1994). Simplifedmethylene blue method for rapid determination of cation exchange capacity of mineral soils. Soil Sci.Plant Anal. 25:3357- 3364.

Shayaa, H. and Hussein, W.A. (2019). Effect of Neem (Azadirachta indica) leaves extract and organic fertilizer in the productivity and quality of two Potato es Varieties, Iraqi Journal of Agricultural Sciences 50(1): 275-285.

Soltanpour , P. N., and A. P. schwab (ed.). (1977). Anew soil test for simultaneous extraction of macro-and-micro-nutrients alkaline soils. Commun. soil sci. plant Anal.8:195-207.

USDA, .(1954). Diagnosis and improvement of saline and alkali soils . Agriculture hand book No.60. USDA Washington .

Van Alphen, J.G. and F.D. Rios Romero. (1971). Gypsiferous Soils. Notes on characteristics and mangment. Int. Ints. Land Rec and Impro. Bulletin 12. Wegeningen, The Netherlands.

Youdeh, Muhammad Qasim.(2018). The role of the source of organic fertilizer and the level of mineral fertilizer in the availability of some nutrients and the growth and yield of potato (Solanum tuberosum L.). Master Thesis, College of Agricultural Engineering Sciences - University of Baghdad.

ISSN 2072-3857