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Effect of chelated iron and zinc application on some growth characteristics of cauliflower plant *Brassica oleracea* var.botrytis in gypsiferous soil

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ABSTRACT

Afield experiment was conducted out during Autumn agricultural season 2021-2022 at research station of soil sciences department and water resources, Agriculture collage, University of Tikrit. This study was established to investigate the effect of ground fertilizer with chelated iron and Zinc on growth characteristics of cauliflower (*Brassica* oleracea var.botrytis) in gypsum soil. It was carried out using randomized complete block design (RCBD). Two factors were included in this study, first factor was micronized chelated iron (Fe-EDDHA) added in three levels (0,4,8) Kg per ha^{-1}, namely (F_0, F_1, F_2) respectively, concentration of iron in this product was 6%. Second factor was micronized chelated Zinc (ZnEDTA) added in four levels (0,1,2,4) Kg per ha^{-1}, namely (Zn_0, Zn_1, Zn_2, Zn_3) respectively, concentration of zinc in this product was 19%. Results showed that adding chelated iron to the ground in recommended quantity (Fe_2)led to a significant increase in stem diameter (52.95 cm), number of leaves (27.21 leaf $plant^{-1}$), plant height (80.81 cm), leaf area (66307 cm^2), and relative chlorophyll (1.01 mg g^{-1}). Results also showed that the addition of ground chelated zinc twice the recommended amount(Zn_3) led to a significant increase in stem diameter amounted to (53.66 cm), number of leaves amounted to (27.15 leaf $plant^{-1}$), plant height reached (82.42 cm) and leaf area reached (67224 cm^2). Results of the research showed that interaction between chelated iron and zinc led to a significant increase, treatment (Zn_3Fe_2) excelled in stem diameter (54.06 cm), number of leaves (28.60 leaf $plant^{-1}$), plant height (86.20 cm), leaf area (72830 cm^2), and relative chlorophyll (1.08 mg g^{-1}).

تأثير إضافة الحديد والزنك المخلبيين في صفات النمو لنبات القرنابيط *Brassica* oleracea var.botrytis في تربة جبسية

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الخلاصة

نفذت تجربة حقلية خلال الموسم الزراعي الخريفي 2021-2022 م في محطة الابحاث التابعة لقسم علوم التربة والموارد المائية في كلية الزراعة – جامعة تكريت , بتصميم القطاعات العشوائية الكاملة (RCBD) تضمنت التجربة (12) معاملة ناتجة عن التوافق بين ثلاث مستويات من الحديد المخلبي المايكروني (EDDHA-Fe) وهي (8,4,0) كغم سماد هكتار $^{-1}$ تركيز الحديد فيه 6% ورمز لها (F_2,F_1,F_0) على الترتيب ,واربع مستويات من الزنك المخلبي المايكروني (ZnEDTA) وهي (4,2,1,0) كغم سماد هكتار $^{-1}$ تركيز الزنك فيه 19% ورمز لها (Zn_3,Zn_2,Zn_1,Zn_0) على الترتيب ,بهدف دراسة تأثير الاضافات الارضية للحديد والزنك المخلبيين في صفات النمو لنبات القرنابيط *Brassica* oleracea var.botrytis في تربة جبسية . اظهرت النتائج ان اضافة الحديد المخلبي ارضيا بالكمية الموصى بها ادى الى زيادة معنوية في قطر الساق بلغت (52.95 سم) وعدد الاوراق بلغ (27.21 ورقة نبات$^{-1}$) وارتفاع النبات (80.81 سم) والمساحة الورقية (66307 سم^2) والكلورفيل النسبي (1.01 ملغم غرام $^{-1}$) كما بينت النتائج ايضا ان اضافة الزنك المخلبي ارضيا بضعف الكمية الموصى بها ادى الى زيادة معنوية في قطر الساق بلغت (53.66 سم) وعـدد الاوراق بلغ (27.15 ورقة نبات$^{-1}$) وارتفاع النبات بلغ (82.42 سم) و المساحة الورقيـــة بلـــغ (67224 سم^2) اظهرت نتائج البحث ان التداخل بين الحديد والزنك المخلبيين ادى الى زيادة معنوية اذ تفوقت المعاملة (Fe_2Zn_3) في جميع صفات النمو الخضري للنبات والمتمثلة بقطر الساق (54.06 سم) و عدد الاوراق (28.60ورقة نبات$^{-1}$) وارتفاع النبات (86.20 سم) و المساحة الورقية (72830 سم^2) و الكلوروفيل النسبي (1.08 ملغم غم$^{-1}$)

الكلمات المفتاحية :(حديد مخلبي, زنك مخلبي ,تربة جبسية ,نبات القرنابيط,)

INTRODUCTION

One of the critical problems that most countries in the world face is food shortage. This is because the rates of agricultural crop production are not commensurate with the increase in population in those countries, in addition to decrease in productivity per unit area. This is due to not being used scientific methods in agricultural operations. Gypsum soil are distributed around the world including Iraq, where they represent about 20% of its area (Al-Barzanji et al., 1986). Due to the expansion of the agricultural area, this requires the exploitation of these soils with the latest scientific methods and techniques and successful management.

Gypsum soils are characterized by the deterioration of their fertility, physical, biological and chemical characteristics. They are characterized by a high percentage of calcium sulphate, low percentage of clay and organic matter. Therefore, ability of Gypsum soil to supply nutrients is low. As gypsum dissolves in soil solution, causing an imbalance in the nutrients as a result of the saturation of soil solution with sulphate calcium ions, and then its effect on the availability of nutrients, as well as growth and spread of roots (Alwan, 2011).

Zinc plays an important role in plant growth and development, It is involved in process of respiration, energy production and representation of ATP, as well as in enzymatic reactions, construction of fatty, amino and nuclear acids. It also contributes to many biological processes such as cell proliferation and the integrity of cellular membranes. Infants and their development (Al Nuaimi, 1999). Zinc also participates in many functions of plant cells, formation of plasma membrane and has a major role in protecting plant cells from oxidative stress (Abu Dahi and El-Younes, 1988; Sharifi, 2016).

As for iron element, it has an important role in formation of chlorophyll. This leads to an increase in vegetative growth, which is reflected positively on production of crop and increase its components. It also enters into the formation of a compound Ferredoxin which is the first compound in the chain of electronic transmission of a number of processes in the plant (Al-Sahhaf, 1989, Barker and Stratton, 2015, Naresh et al., 2022).

Cauliflower is an important crop in Brassicaceae family. Cauliflower is grown for the fused pink disc (curds), which is edible part of the plant. It consists of floral buds before opening with flower stalks that are fleshy and enlarged (Matloob et al., 1989),(FAO, 2019). Cauliflower has been mentioned to have high percentage of protein, carbohydrates, iron, calcium, and phosphors (Devi and et al 2018).

The aim of this study is to investigate the effect of terrestrial chelated iron and zinc additions on vegetative growth of cauliflower plants.

MATERIALS AND METHODS

The experiment was carried out at research station, Department of Soil Sciences and Water Resources, College of Agriculture, University of Tikrit, in the agricultural season 2021-2022. Cauliflower seedlings (F1 Hybrid of Dutch origin) were bought from trusted company and planted on 22-9-2021 in sandy loam soil with the aim of study the effect of ground feeding with chelated iron and zinc on growth characteristics of cauliflower plants in gypsum soil. The soil of field experiment was by plowed, leveled and divided into three sectors, and each sector included (12) experimental units with an area of 4.8 m^2. (2m in length and 2.4m in width) the experimental unit had two terraces, the distance between one and another is (0.80m), leaving (0.50m) between experimental units, and (1m) between sectors to prevent transfer of nutrients between experimental treatments. The distance between one seedling and another is (0.40m) and cultivated alternately on the terrace.

Number of seedlings in each experimental unit was (12), with (6) seedlings per terrace. Field was irrigated using the drip irrigation method, according to the plant's need for water. The experiment included (12) treatment resulting from the compatibility between three levels of micronized chelated iron (Fe-EDDHA) (0.4.8) kg ha^{-1} iron concentration is 6%. And it’s code (F_0, F_1, F_2), respectively. And four levels of micronized chelated zinc in form of (ZnEDTA), which is (0,1,2,4) kg ha^{-1}. The concentration of zinc is 19%. and its symbol is (Zn_0, Zn_1, Zn_2, Zn_3), respectively. The coefficients were distributed in a factorial experiment with three replications according to randomized complete block design (RCBD), the following characteristics were measured:

1- Stem diameter (cm): The diameter of stem was measured at a distance of (5 cm) from its contact with flowering disc by means of a Vernier machine for five plants, the average was taken from each experimental unit.

2- Number of leaves (leaf $plant^{-1}$): according to number of leaves for (5) plants and extracting the average of there.

3- Plant height (cm): height of plant was measured from soil surface to the top using a measuring tape for five plants, its average was extracted from each experimental unit.

4- Leaf area (cm^2): leaf area of five plants was measured by gravimetric method, the average was taken from each experimental unit according to the method (Dvornic, 1965).

5-Total relative chlorophyll content (mg^{-1}): total relative chlorophyll content of five plants was measured according to (Knudson et al., 1977) using a spectrophotometer.

Table (1) **some of physical and chemical characteristics of soil**

Character	**Unit**	**Value**	**character**	**unit**	**Value**
Sand	gm kg^{-1}	584			
Loam		304			
Clay		112	Soluble ions		
Soil texture	Sandy loam				
pH(1:1)		7.4	Ca^{+2}		10.75
Ec (1:1)	Dsm^{-1}	3.26	Mg^{+2}		5.09
Ion exchange capacity	Santi mol. kgm^{-1}	14.22	K^{+1}		0.62
Organic matter		9.1	Na^{+1}		1.37
Carbonate minerals	gm kg^{-1}	130	Cl^{-1}	m mol^{-1}	2.52
Gypsum		107.5	SO_4^{-2}		11.83
Available potassium		137	CO_3^{-2}		Nill
Available nitrogen	mg kg^{-1}	21.82	HCO_3^{-1}		1.92
Available phosphor		3.56			
Available iron		1.214			
Available zinc		2.827			

RESULTS AND DISCUSSION

Results of Table (2) showed that ground addition of chelated zinc led to a significant increase in stem diameter for all levels of addition compared to control treatment. Zn_3 level gave the highest value of stem diameter (53.66 cm), which did not differ significantly from Zn_2 level, with a percentage increase (7%) compared to control treatment. As for the effect of chelated iron, it was found that ground addition of chelated iron led to a significant increase in diameter of stem (cm). level (Fe_2) gave highest value of stem diameter (52.95 cm) compared to control treatment (51.26cm), with a percentage increase (3.3%). The interaction between two studied factors led to a significant increase in stem diameter (cm) of cauliflower, treatment (Zn_3Fe_2) gave highest value of stem diameter (54.06 cm), with an increase of (11.7) compared to control treatment (48.40cm).

Table (2) **effect of chelated iron and zinc application and overlap in leg diameter (cm) of cauliflower plants**

Zn / Fe	**Zn0**	**Zn1**	**Zn2**	**Zn3**	**Means Fe**
Fe0	48.40	51.46	51.86	53.33	51.26
Fe1	50.33	51.53	52.20	53.60	51.91
Fe2	51.73	52.46	53.53	54.06	52.95
Means Zn	50.15	51.82	52.53	53.66	

LSD		
Fe	Zn	Fe*Zn
1.43	1.65	2.87

Results of Table (3) showed that ground addition of chelated zinc led to a significant increase in number of leaves. level (Zn_3) gave highest value (27.15leaf plant^{-1}) with an increase (7.1%) compared to control treatment. Level (Fe_2, Fe_1) were significantly higher than control treatment with an increase of (8.2%) and (4.4%) respectively. level (Fe_2) was significantly higher than (Fe_1) with an increase of (27.21 leaf plant^{-1}) and (26.25 leaf plant^{-1}) respectively. interaction between two studied factors led to a significant increase in number of leaves of cauliflower plants, treatment (Fe_2 Zn_3) excelled over the rest of the treatments and gave highest value of (28.60 leaf plant^{-1}) with a percentage increase of (17.8%) compared to control treatment. While control treatment (Fe_0 Zn_0) gave least significant value in number of leaves recording (24.26 plant^{-1} leaves).

Table (3) **effect of chelated iron and zinc application and overlap in leaves number (leaf plant^{-1}) of cauliflower plants**

Zn / Fe	**Zn0**	**Zn1**	**Zn2**	**Zn3**	**Means Fe**
Fe0	24.26	25.06	25.40	25.80	25.13
Fe1	25.40	25.80	26.73	27.06	26.25
Fe2	2640	26.46	27.40	28.60	27.21
Means Zn	25.35	25.77	26.51	27.15	

LSD		
Fe	Zn	Fe*Zn
0.83	0.96	1.67

Results of Table (4) showed that ground application of chelated zinc led to a significant increase in plant height for all levels of addition, compared to control treatment. level (Zn_3) was significantly higher than (Zn_2) and (Zn_1), recording (82.42cm), (80.13cm), (78.17cm) respectively. As for the effect of chelated iron, it was found that terrestrial addition of chelated iron led to a significant increase in plant height (cm) for all levels of addition compared to control treatment. level (Fe_2) was significantly higher than (F_1) level with an increase (6.1%). Interaction between two studied factors led to a significant increase in plant height (cm) for all addition treatments compared to control treatment. Treatment (Fe_2Zn_3) gave the highest value (86.20 cm), which was significantly higher than other treatments. comparison treatment (Fe_0Zn_0) gave the lowest value (68.40 cm).

Table (4) effect of chelated iron and zinc application and overlap in plant height (cm) of cauliflower plants.

Zn / **Fe**	**Zn0**	**Zn1**	**Zn2**	**Zn3**	**Means Fe**
Fe0	68.40	77.80	78.40	80.06	76.16
Fe1	74.40	77.73	79.53	81.00	78.16
Fe2	75.60	79.00	82.46	86.20	80.81
Means Zn	72.80	78.17	80.13	82.42	

LSD		
Fe	Zn	Fe*Zn
1.89	2.19	3.79

Results of Table (5) showed that ground addition of chelated zinc led to a significant increase in leaf area (cm^2). Level (Zn3) gave an average (67224) cm^2 with an increase by (24.6%) compared to control treatment (Zn0), which gave the lowest value (53939) cm^2.
As for the effect of chelated iron, it was found that ground addition of chelated iron led to a significant increase in leaf area (cm^2) for all levels of addition. Level (Fe_2) gave the highest value amounting to (66307) cm^2, which did not differ significantly from level (Fe_1). Control treatment gave the lower value (51566) cm^2. Interaction between two studied factors led to a significant increase in leaf area (cm^2) for all interaction treatment. Treatment (Fe_2Zn_3) gave highest value (72830) cm^2. There were no significant differences between interaction treatments. Control gave the lowest value, recording (42936) cm^2.

Table (5) **effect of chelated iron and zinc application and overlap in leaf area (cm^2) of cauliflower plants**

Zn / **Fe**	**Zn0**	**Zn1**	**Zn2**	**Zn3**	**Means Fe**
Fe0	42936	53203	53289	56834	51566
Fe1	57467	58901	67746	72008	64030
Fe2	61414	62224	68760	72830	66307
Means Zn	53939	58110	63265	67224	

LSD		
Fe	Zn	Fe*Zn
9835.4	11357	19671

Results of Table (6) showed that ground application of chelated zinc did not lead to a significant increase in relative chlorophyll in leaves of cauliflower plants for all levels of additions. As for the effect of chelated iron, it was found that ground addition of chelated iron led to a significant increase in relative chlorophyll in leaves of cauliflower plant and for all levels of addition. level (Fe_2) gave the highest value amounting to (1.01) mg g^{-1} With an increase by (32.8%) compared to control. (Fe_2) treatment did not different significantly from the level (Fe_1). Interaction between two studied factors led to a significant increase in relative chlorophyll in leaves of cauliflower plant. Treatment (Fe_2Zn_3) was significantly higher than control with an increase by (89.4%).

Table (6) **effect of chelated iron and zinc application and overlap in relative chlorophyll in leaves of cauliflower plants**

Zn Fe	**Zn0**	**Zn1**	**Zn2**	**Zn3**	**Means Fe**
Fe0	0.57	0.63	0.69	0.81	0.67
Fe1	0.83	0.88	0.91	0.93	0.89
Fe2	0.98	0.98	0.99	1.08	1.01
Means Zn					

LSD		
Fe	Zn	Fe*Zn
0.1865	0.2154	0.373

As soil was poor in zinc element (Table 1), results of Tables (2), (3), (4), (5) and (6) indicated that ground addition of chelated zinc led to a significant increase in vegetative growth characteristics represented by stem diameter, number of leaves, plant height and leaf area. Diameter of stem and plant height indicate main role of zinc in manufacture of amino acid tryptophan, which is important in formation of hormone indole acetic acid (IAA), which affects the increase in cell division and stimulates the activity of meristematic cells, their division and expansion. Zinc also participates in many functions of plant cells, formation of plasma membrane and has a major role in protecting plant cells from oxidative stress (Abu Dahi and El-Younes, 1988; Sharifi, 2016). Perhaps increase in number of leaves is due to the role of zinc as a necessary element to stimulate plant growth and leaf formation because of its major role in regulating sugars and enzymes (Yadav et al., 2002). It has been indicated that Zinc element has an effect on photochemistry, chloroplast construction, and photoelectron transport, as well as carbon synthesis (Kumar et al., 1988; Marschner, 1995). Increase in leaf area may be due to zinc role in improving some properties of plant and its role in increasing efficiency of leaves by carrying out process of carbon metabolism, activating enzyme (carbonic anhydrase), stimulating activity and activity of the enzyme Ribonuclease, which is reflected in carbon metabolism (Mengel et al., 2001). As a result, leaf area increased and these results agree with what was reached by Verma et al. (2022) and Akter (2017) when using ground fertilization and fertilizing broccoli with chelated zinc respectively.

As soil was poor in iron element (Table 1), results of Tables (2), (3), (4), (5) and (6) showed that ground addition of chelated iron led to a significant increase in vegetative growth characteristics represented by stem diameter, number of leaves, plant height, leaf area, and relative chlorophyll. These increase in the diameter of stem, number of leaves, height of plant and chlorophyll may be related to the role of iron in activation of redox enzymes that participate in the electron transport chain in the process of respiration, which was reflected in increase in diameter of the stem and number of leaves. The reason may be attributed to the role of iron in manufacture of chlorophyll through the entry of iron into enzyme Caproporphyrin0gen Oxidase, which is an enzyme participating in the sixth step of porphyrin metabolism and its necessity in manufacture of a-amino Levulinic acid, which is the raw material for building chlorophyl (Barker and Stratton, 2015). These results are consistent with what was reached by (Naresh et al., 2022) when ground supplementation of chelated iron to cauliflower plants increased the accumulation of iron in chloroplasts, which was reflected in increased vegetative growth (Sharif et al., 2020). These results are in harmony with what has been reached Tsiakaras et al. (2016) when fertilizing with chelated iron on cauliflower and lahana plants. The reason for increasing plant height is attributed to the role of chelated fertilizers that facilitate the availability of elements in soil and make them absorbable by plant. This leads to an increase in proportion of iron element in plant, which increase efficiency of carbon metabolism, plant activity and then increase its height. The reason for increase in leaf area is that iron is included in Ferredoxin composition which acts as a carrier of electrons in process of carbon synthesis, sulfite reduction nitrate reduction and nitrogen fixation. It is included in composition of cytochromes, which play role of transporting oxygen in respiration and carbon metabolism (Barker and Stratton, 2015).

As soil was poor in zinc and iron elements (Table 1), results of Tables (2), (3), (4), (5) and (6) showed that ground addition of chelated iron and zinc led to a significant increase in vegetative growth characteristics represented by stem diameter, number of leaves, plant height, leaf area and chlorophyll. This increase may be related to role of Zinc in plant growth and development, and the role of chelated iron on nutrient absorption. Zinc is also effective in plant nutrition to manufacture plant hormones and achieve balanced absorption of phosphorus and potassium within plant cells (Sharma et al., 2013). These led to an increase in plant activity by increasing process of carbon synthesis and then improving vegetative growth characteristics of plant. This increase may be due to the presence of chelated zinc and iron, as they worked to increase the efficiency of nitrogen utilization and its absorption from soil, then increase number of leaves and plant height (Askary et al., 2017). These results are consistent with what was achieved by (Lashkari et al., 2007) when fertilizing with zinc and iron on cauliflower.

CONCLUSIONS

Ground addition with chelated zinc and iron improved most of vegetative growth characteristics of cauliflower. Interaction between chelated zinc and iron led to a significant superiority in most of vegetative growth characteristics of cauliflower. Ground fertilization with chelated iron and zinc increased available amount of these two elements in soil after harvest. Use of scientific methods in good management and how to deal with gypsum soils can make them soils with good productivity, especially after overcoming their physical, chemical and fertility problems that reduce the productivity of these soils.

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