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Spaying effect of Copper and Iron on Strawberry (*Fragaria ananassa*) seedlings grown in non-air-conditioned greenhouses in AL-Najaf Governorate.

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Abstract

The study was conducted in a non-air-conditioned plastic house located in the nursery of the Horticulture and Forestry/ Department of Plant Production / Al-Najaf Agriculture Directorate. The study was observed from (1/11/2021) to (1/6/2022). Randomized Complete Block Design (RCBD) was adopted as a factorial experiment (3*3) with three replications in each replicate. The first studied factor was three concentrations of copper (H2O5 (CuSO4) that were (0,5,2.5) $mg.L^{-1}$ while the second factor was three concentrations of iron that were (0.25, 50) $mg.L^{-1}$ and the interactions between them. The study included 27 experimental units. every experimental unit has 10 plants within. The means of the properties were analyzed using the Genstat statistical analysis program. Dunkin's multiple range test at the probability level of 0.05 was used to compare the means.

The most important results can be summarized as follows:

1- The copper element showed a significant effect on all vegetative and yield indicators of the strawberry plant. These indicators were plant height, number of leaves, number of fruits, the weight of fruits, and the percentage of total sugars in fruits which excelled at a concentration of 5 $mg.L^{-1}$ to record 7.17 cm. $plant^{-1}$, 11.40 leaves. $plant^{-1}$, 22.44 fruits. $plant^{-1}$, 26.85 g. 00 grams fresh $weight^{-1}$ compared to the comparison treatment that gave the lowest value of 6.69 cm. $plant^{-1}$, 11.7 leaves. $plant^{-1}$, 16.00 fruits. $plant^{-1}$, 17.50 gm. $plant^{-1}$, 3.47 g. 100 grams fresh $weight^{-1}$ respectively.

2- Foliar application of iron at a concentration of 50 $mg.L^{-1}$ increased the characteristics of plant height, number of leaves, number of fruits, the weight of fruits, and the percentage of total sugars in the fruits which recorded 6.69 cm. $plant^{-1}$, 16.59 leaves. $plant^{-1}$, 22.11 fruits. $plant^{-1}$, 23.70 gm. $plant^{-1}$, 4.08 g. 100 grams fresh $weight^{-1}$ compared to the control treatment that gave the lowest value of 6.53 cm. $plant^{-1}$10.04

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leaves. plant^{-1}, 15.11 fruits. plant^{-1}, 16.82 gm. plant^{-1}, 3.24 g. 100 grams fresh weight^{-1} respectively.

Introduction

Strawberry Fragaria X ananassa Duch, which is belonged to the Rosaceae family, is one of the most important and widely distributed small fruit groups in the world (Manganaris *et al*., 2014). Strawberry is a perennial plant that adapts to a wide range of climates (Zhao, 2007). It has more than 2000 different varieties spread in Europe, Asia, and North America. It is believed that the original home of Strawberries is the regions of the Alps and the Massif Central region in France, and from there it spread to the rest of Europe and North Asia, and then it's cultivated and spread to the rest of the world (Al-Saidi, 2000). Strawberry cultivation began to spread recently in Iraq on a commercial scale, specifically at the beginning of the current century. Although there were previous attempts by the private and public sectors, they were modest attempts due to the lack of experience in the field of cultivation and production of this crop (Muhammad, 2018).

Iron and copper are important elements for plant growth. Where copper participates in the vital processes of protein formation and plays a role in the process of carbon metabolism through its role in the formation of chlorophyll, as a high percentage of total copper is found in chloroplasts. It also participates in the synthesis of some enzymes such as Cytochrome Oxidase, Ascorbic acid Oxidase. In addition, copper participates in the electronic transport chain that connects the two photochemical reaction systems for carbon representation and is a catalyst in the formation of DNA and RNA (Szaciłowski *et. al.*, 2005) which works to improve plant growth. The availability of copper is affected by the degree of soil interaction if the readiness is less when the soil PH rises above 7 (Lauchli *et. al.*, 2005).

On the other hand, iron has physiological importance due to its role in the oxidation and reduction processes that occur in plant tissue and in the construction of chlorophyll. Iron also is involved in the composition of cytochromes that are important in the process of photosynthesis, as well as the formation of plant proteins (Mengel and Kirkby, 2012). In addition, it participates in the formation of chlorophyll, although it is not included in its composition. Recent studies have indicated the role of iron in the process of forming RNA and its importance in the process of protein formation (Focus, 2003).

Therefore, the aim of this study is to increase the growth and yield of the strawberry plant by spraying the plants with iron and copper elements in different concentrations. Also, the study aims to create all the conditions and requirements to increase the strawberries cultivated area in the province of Najaf, as well as the other provinces of Iraq.

Materials and Methods

The experiment was carried out in one of the non-air-conditioned plastic houses of the nursery of the Horticulture and

Forestry / Plant Production Department /Al-Najaf Agriculture from (1/11/2021) to (1/6/2022). The soil of the plastic house was divided into trays of 0.80 m width, 0.30 m height, and 26 m length. Half a meter at the beginning and end of the plastic house was left, planting seedlings of the same variety. Seedlings were planted on 1/11/2021 with double lines so that the distance between the two lines is 0.20 m. The distance between one plant and another within one line is 0.30 m. The distance between one terrace and another is 1.40 m. The operation services were carried out by weeding and irrigation. The drip irrigation system was followed with a drainage rate ranging between 3.5-4 liters $.h^{-1}$ whenever needed. In addition, the fertilization operations are carried out uniformly for all treatments according to the fertilizer program approved in most of strawberry farms.

The soil was analyzed in the laboratory of the Al-Najaf Agriculture Directorate to measure the physical and chemical properties, and the results were as shown in Table (1).

Table (1) Analysis of some chemical and physical properties of soil

the soil			
property		value	measuring unit
	sand	380	
Soil articulations	silt	308	$gm.kg^{-1}$
	clay	312	
texture	clay loam		----
pH		7.4	
EC electrical conductivity		1.7	Decismens. M^{-1}
CO3		Nil	
N nitrogen		0.261	PPm
P.P		0.245	PPm
K potassium		92.2	PPm
Calcium Ca		4	$mmol.L^{-1}$
Magnesium Mg		9.6	$mmol.L^{-1}$
Cl chloride		5	$mmol.L^{-1}$
HCO3		0.7	$mmol.L^{-1}$
SO4		0.42	$mmol.L^{-1}$

Transactional procedure and experimental design

The study is carried out according to the Randomized Complete Block Design (RCBD) in a factorial experiment (3 * 3) with three replications. The first factor was three concentrations of copper (H2O5 (CuSO4) that are (0,5,2.5) $mg.L^{-1}$ while the second factor was three concentrations of iron that are (0,25,5) $mg.L^{-1}$. The overlap between the factors was studied. The experiment includes 27 experimental units, each unit includes 10 plants, and a program is used Genstat in statistical analysis.

Studied indicators

Five plants were taken from each experimental unit for the measurement

2-2 Vegetative indicators

1- Plant height (cm)

Plant height is measured from the soil surface to the top of the plant.

2- The number of leaves (leaf.plant^{-1})

The number of leaves is calculated for three plants from each experimental unit, and then the average number of leaves per plant is calculated

3- Number of fruits (fruit, plant^{-1})

According to the number of fruits for all fairies and divided by the number of plants in the experimental unit.

4- Weight of the fruit (gm. fruit^{-1})

Calculated according to the following equation

Fruit weight (gm.fruit^{-1}) = total weight of fruits of one plant/number of fruits of the same plant.

5- Fruit content of total sugars (gm. 100 gm fresh weight^{-1}):

It was measured by a Digital Refract meter model DR201-95 manufactured by the German company Kruss (Moldovan *et al*., 2015).

3- Results and discussion

3-1 Effect of spraying copper and iron elements and their interaction on the vegetative and yield indicators of strawberry plant

Table (2, 3, and 4) shows that spraying the copper element (5 mg.L^{-1}) was significantly superior. It gave the highest value for the studied characteristics including plant height, number of leaves, number of fruits, fruit weight, and the percentage of total sugars in the fruits which scored 17 cm. Plant^{-1}, 11.40 leaves. Plant^{-1}, 22.44 fruits. Plant^{-1}, 26.85 gm. Plant^{-1}, 3.65 gm. 100g fresh weight^{-1} compared to the control treatment which gave the lowest value of 6.69 cm. plant^{-1}, 11.7 leaves. plant^{-1}, 16.00 fruit. plant^{-1}, 17.50 g. plant^{-1}, 3.47 g. 100 grams fresh weight^{-1} respectively.

The same tables show the superiority of (05 mg.l^{-1})iron concentration over the rest of the concentrations in some properties including plant height, number of leaves, number of fruits, fruit weight, and the percentage of total sugars in fruits. It gave 6.69 cm. plant^{-1}, 16.59 leaves. plant^{-1}, 22.11 fruits. plant^{-1}, 23.70 gm. plant^{-1}, and 4.08 gm. 100 grams fresh weight^{-1} compared to the control treatment which gave the lowest value of 6.53 cm. plant^{-1}, 10.04 leaves. plant^{-1}, 15.11 fruits. plant^{-1}, 16.82 gm. plant^{-1}, and 3.24 g. 100 grams fresh weight^{-1} respectively.

The interaction between spraying the copper and iron elements at a concentration of (5 mg.L^{-1} + 50 mg.L^{-1}) showed a significant effect on the vegetative and yield properties of the strawberry plant. This interaction gave the highest value of 8.50 cm. plant^{-1}, 20.57 leaves. plant^{-1}, 24.33 fruits. plant^{-1}, 33.45 gm. plant^{-1}, and 4.16 gm. 100 grams fresh weight^{-1} compare to the control treatment which gave the lowest value of 4.63 cm. plant^{-1}, 8.93 leaves. plant^{-1}, 12.67 fruits. plant^{-1}, 12.65 gm. plant^{-1}, and 3.17 g. 100 grams fresh weight^{-1} respectively.

The increase in these characteristics due to spraying with copper may be attributed to the role of this element, which participates in many vital processes of the plant. Copper helps synthesize a number of enzymes such as cytochrome oxidase, Ascorbic acid oxidase, and others. Copper participates in the synthesis of the protein since it induces the formation of RNA and DNA which are essential to build protein.

It also participates in the vital processes of carbohydrates. The levels of reduced sugar are decreased by the shortage of this element during the electronic transition in the process of photosynthesis. Copper is one of the micro-nutrients necessary for plant growth, as it enters the formation of chloroplasts of the protein Plastocyanin (Rai *et. al.*, 2021).

Table (2) the effect of spraying copper and iron on the vegetative growth index of the strawberry plant

	Plant height (cm.plant^{-1})				Number of leaves (leaf. plant^{-1})			
copper / Iron	0	2.5 mg.L^{-1}	5 mg.L^{-1}	mean	0	2.5 mg.L^{-1}	5 mg.L^{-1}	mean
0	4.63a	7.29c	7.67c	6.53ab	8.93c	10.53bc	10.67bc	10.04 b
25 mg.L^{-1}	8.07c	5.21ab	5.35ab	6.21ab	7.93c	11.20bc	11.97bc	11. 3b
50 mg.L^{-1}	7.37b c	8.22c	8.50c	6.69a	16.87a b	12.33bc	20.57a	16.59a
mean	6.69a	6.90a	7.17a		11.75a	11.24a	11.40a	

Table (2) the effect of spraying copper and iron on the yield parameters of the strawberry plant

	Number of fruits (fruit. plant^{-1})				Fruit weight (gm. plant^{-1})			
copper / Iron	0	2.5 mg.L^{-1}	5 mg.L^{-1}	mean	0	2.5 mg.L^{-1}	5 mg.L^{-1}	mean
0	12.67a	13.67ab	19.00ab c	15.11 a	12.65c	17.96bc	19.85ab c	16.82a b
25 mg.L^{-1}	16.00ab c	15.33ab c	23.00c	17.22 ab	20.71ab	22.36abc	27.26ab c	23.44b
50 mg.L^{-1}	19.33ab c	23.67c	24.33c	22.11 b	19.16ab c	18.50bc	33.45a	23.70a
mean	16.00 a	17.55 ab	22.44b		17.50a	19.61a	26.85b	

Table (2) the effect of spraying copper and iron on total sugars in fruits of the strawberry plant

	Total sugars in fruits (gm. 100 gm fresh weight^{-1})			
copper / Iron	0	2.5 mg.L^{-1}	5 mg.L^{-1}	mean
0	3.17 ab	3.01 ab	3.55 ab	3.24a
25 mg.L^{-1}	3.43 ab	3.60 c	3.24 ab	3.42a
50 mg.L^{-1}	3.81 b	4.16a	4.16 a	4.08ab
mean	3.47 ab	3.59 ab	3.65 a	

Iron is an important micronutrient in the processes of oxidation, reduction, and the formation of chlorophyll. It has an importance in photosynthesis, the formation of many cytochromes, and ferredoxin compounds which are reflected in growth rates (Goh *et al*., 2000). Iron can also increase the leaf area of the plant. Abu Dahi and others (2009) indicated that by increasing the leaf area, most of the nutrition is synthesized and transferred to the rest of the plant parts.

Spraying iron on the plant leaves during the different growth stages leads to improving the growth of the crop and production and improving its quality as well as increasing the efficiency of utilization of nutrients and reducing their use (Singh *et al*., 2017). Iron has a fundamental role in the growth and development of plants, including the synthesis of chlorophyll and the development of chloroplasts. Iron is included in the vital structures of the plant such as biosynthesis and photosynthesis in the plant (Kazemi, 2014). In addition, iron has the ability to increase the content of chlorophyll, which was accompanied by an increase in food formation products, which led to an increase in plant absorption of this element (Abdzad *et al*., 2010).

Iron is an essential element for plant growth, chlorophyll synthesis, respiration, redox processes within plant tissues, and the synthesis of important cytokines in photosynthesis (Sheykhbaglou *et al*., 2010). It has a role in improving the color of the leaves, increasing their ability to absorb solar energy, and increasing the thickness of the leaves. This leads to increase absorption of nutrients and improved plant growth (Uchida, 2000).

Conclusions

1- The results of the study showed that spraying with copper acid led to a significant superiority at a concentration of 5 mg.L^{-1}, as it gave positive results in most of the studied indicators, while there were not many differences in the comparison treatment.

2- The results of the study showed that iron spraying at a concentration of 50 mg.L^{-1} gave a significant increase in the studied indicators.

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