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EFFECT OF NANO-IRON AND NANO-ZINC ON SOME GROWTH CHARACTERISTICS, CHEMICAL COMPONENTS AND OIL OF BASIL PLANT (*OCIMUM BASILICUM* L.)

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Abstract:
This study was carried out in an agricultural field in the College of Agriculture and Marshes - Thi-Qar University. The experiment aimed to investigate the effect of Nano-iron and Nano-zinc on the vegetative growth characteristics, chemical components and oil of basil plant. The study included two main factors and their overlap with three replications for each factor using a randomized complete block design (RCBD). The study included twenty-seven experimental units resulting from the compatibility of three concentrations of iron (0, 30, and 60) mg L^{-1} and three concentrations of zinc (0, 20 and 40) mg L^{-1}. The results showed that the Fe_2 treatment was superior to the Fe_1 treatment and the control treatment in terms of plant height, number of leaves, number of branches, leaf content of chlorophyll and carbohydrates, and the percentage of oil, which were (61.56 cm, 92.49 g, 12.60 branches, 15.71 mg100 g^{-1} fresh weight, 172.4 mg g^{-1} dry matter and 10.57%) respectively. While the Zn_2 treatment was superior to the Zn_1 treatment and the control treatment in each of the plant height, the number of branches, the number of leaves and the highest percentage of oil with averages of (54.74, 85.28, 10.73 and 9.215%), while it was not significant in the content of each of the leaves of total chlorophyll and carbohydrates. The interaction treatment Fe_2Zn_2 was superior to the control treatment H_0N_0 and the rest of the treatments in the study in plant height, number of leaves, and percentage of oil only, but it was not significant in the rest of the studied trait characteristics.

Keywords: Basil, Nano-iron, Nano-zinc, Chlorophyll, Carbohydrate, Percentage of Oil

INTRODUCTION

Basil (*Ocimum basilicum* L.) belongs to the genus of Ocimum, which includes 150 species of herbs and shrubs belonging to the Lamiaceae family (Debaggio and Belsinger, 1996). It is an aromatic annual summer shrubby or semi-shrub plant, according to its varieties, with a height of 50-60 cm. It is grown in order to obtain its leaves and seeds, which contain a percentage of volatile oil ranging from 1.0-45.0%, depending on the environmental conditions and plant service. The original homeland of basil is northwestern India, northeastern Africa, and central Asia, then its cultivation has spread widely in Egypt, Morocco, the United States, France, and Indonesia (El-Gendy et al., 2001).

Zinc is one of the essential micronutrients for all living organisms for its role in building proteins, as well as for its essential role in the activity of plant metabolism. It is also essential in the construction of most enzymes and plays an essential role in defending the cell from reactive oxygen species (ROS), and then protects several components of the cell such as plasma membrane proteins, lipids, chlorophyll, enzymes containing SH and DNA from oxidation (Cakmak, 2000). . It has an essential role in the maintenance of cell membranes in plants due to its possible association with the SH group of cell membrane proteins. It is also necessary for the construction of the amino acid tryptophan, the initiator of the construction of IAA, which helps in plant growth and is also necessary for the biosynthesis of chlorophyll, DNA, RNA and protein building (Abdel-Aziz and Balbaa, 2007).

Iron is one of the necessary microelements for crops because it has a role in nitrogen fixation, as it contributes to the activity of legume hemoglobin and is involved in the formation of the nitrogenase enzyme, in addition to its role in many physiological processes and enzymatic reactions of the plant, which leads to increased growth and development of the plant (Al-Naimi, 2000).

Nanotechnology is one of the modern and important technologies that contribute to increasing agricultural production and improving its quality on a large scale. The use of nanomaterials particles is a modern technology used in many fields, including agricultural fields, which aims to increase the absorption of water and nutrients when added to plants, which contributes to raising production in quantity and quality, in addition to its low material cost, and thus reduces the economic costs of the agricultural process (Juthery, 2019-Ali and Al). Foliar feeding is considered one of the

preferred methods because it provides the plant with its need for nutrients during the critical stages of plant growth that the roots cannot meet, which reflects positively on the qualitative and quantitative yield, in addition to being economical, easy and fast, and there are no soil problems with it (Ali, et al; 2014).
The research aims to determine the appropriate concentration of nano-iron and nano-zinc, which contributes to increasing growth and improving basil crop yield

AIM OF THE STUDY

1- Study the effect of iron on the vegetative yield and oil of basil plant.
2- Studying the effect of zinc on the vegetative growth and oil characteristics of basil plant.
3- Studying the effect of the interaction between iron and zinc on the studied properties.

MATERIALS AND METHODS

This experiment was carried out in an agricultural field in the College of Agriculture - Thi-Qar University for the agricultural season 2022-2023 in a soil with a loamy mixture texture. The experiment was designed according to a randomized complete block design with three replicates for each treatment, as shown in Table 1.

Table 1: Experimental Design

Treatment	T0 (C)	T1	T2	T3	T4	T5	T6	T7	T8
Fe (mg L^{-1})	0	0	0	30	30	30	60	60	60
Zn (mg L^{-1})	0	20	40	0	20	40	0	20	40

Experimental measurements

Indicators of vegetative growth

Vegetative growth measurements were taken at the end of the growing season for each appointment of five plants in each unit
Experimental included:-
1- Plant height (cm): The height of the selected plants in each experimental unit was measured from the soil surface to the top of the plant by means of a tape measure and its average was recorded.
2- The number of main branches
The number of main vegetative branches of the selected plants in each experimental unit was calculated and averaged.
3- The number of leaves
The total number of leaves in each of the selected plants in each experimental unit was calculated.
4- Percentage of volatile oil
The percentage of oil in the seeds in each treatment was estimated according to the following equation:
The percentage of volatile oil = (weight of the resulting oil (g)) / (weight of the seeds (g)) x 100
5- Leaves content of total chlorophyll (mg per 100g fresh weight)
The total chlorophyll pigment in the leaves was estimated according to the Goodwin (1976) method, as it was extracted by acetone 80% and estimated by a spectrophotometer to measure the optical absorption at the two wavelengths of 645 and 665 nm and according to the following equation:
Total chlorophyll (mg.$100g^{-1}$) = 20.2(D645+8.02(D665)) X 1000-W/V
6- Leaves content of total soluble carbohydrates (mg g^{-1})
Carbohydrates were estimated in dry leaves by the Phenol - Sulfuric acid Colorimetic method (Dubois et al., 1956).

RESULTS AND DISCUSSION

Plant height (cm)

The results of the statistical analysis in Table (2) showed that there were significant differences between the averages of the treatments for the addition of iron and zinc in plant height. The plants treated with iron excelled as the highest plant height was 61.56 cm compared to the lowest height of 41.00 cm obtained from the comparison plants. The plants treated with zinc also excelled by giving the highest height of 54.74 cm compared to the control treatments that gave the lowest height of 46.67 cm. The two-way interaction had a significant effect if the overlap coefficients (T8) gave the highest plant height of 64.00 cm compared to the lowest height of 33.33 cm resulting from the control treatments.

Table 2: Effect of Nano-iron and Nano-zinc on plant height (cm)

Fe (mg L^{-1})	Zn (mg L^{-1})			Nano-Fe Mean Effect	Nano-Zn Mean Effect
	0	20	40		
0	33.33	41.67	33.33	41.00	46.67
30	49.00	51.33	49.00	50.86	52.00
60	57.67	63.00	57.67	61.56	54.74
LSD (0.05)	4.753			2.744	2.744

Number of leaves

The plants treated with iron excelled with the highest number of leaves reaching 92.49 leaves per plant, compared to the lowest number of leaves amounting to 65.92 leaves per plant. Also, the plants treated with zinc (T2) excelled by giving the highest number of leaves, 85.28 leaves per plant. The binary overlap (T8) gave the highest number of leaves of 84.13 leaves per plant compared to the lowest number of leaves of 50.67 leaves per plant produced by the control treatments, as shown in table 3.

Table 3: Effect of Nano-iron and Nano-zinc on leaves numbers

Fe (mg L^{-1})	Zn (mg L^{-1})			Nano-Fe Mean Effect	Nano-Zn Mean Effect
	0	20	40		
0	50.67	73.00	74.10	65.92	71.20
30	76.63	80.43	84.13	80.40	82.33
60	86.30	93.57	97.60	92.49	85.28
LSD (0.05)	3.504			2.023	2.023

The number of branches

It is noted from Table (4) that the plants treated with iron and zinc were significantly superior in this number of branches. The plants treated with iron T6 gave the highest number of branches of 12.60 branches per plant, compared to the lowest number of branches of 6.57 branches produced by the control plants. Also, plants treated with zinc T2 excelled, with the highest number of branches reaching 10.73 branches per plant, compared to the lowest number of 8.77 branches resulting from plants not treated with zinc. Also, the T8 binary overlap showed the highest number of branches, which amounted to 13.53 branches, compared to the lowest number, which reached 8.77 branches, resulting from the control treatments.

Table 4: Effect of Nano-iron and Nano-zinc on braches numbers

Fe (mg L^{-1})	Zn (mg L^{-1})			Nano-Fe Mean Effect	Nano-Zn Mean Effect
	0	20	40		
0	5.03	7.20	7.47	6.57	8.77
30	9.23	9.93	11.20	10.12	9.79
60	12.03	12.23	13.53	12.60	10.73
LSD (0.05)	N.S			0.287	0.287

Leaves content of chlorophyll

The results indicated in Table (5) that there were significant differences when treated with iron. The results showed that there were significant differences between the averages of the treatments, as the nano-iron addition treatment was significantly superior to the T6 treatment, and the highest chlorophyll content was 15.17 mg $100g^{-1}$ fresh weight compared to the control treatment, which gave the lowest chlorophyll content of 11.35 mg $100g^{-1}$ fresh weight. While the treatment with nano-zinc and the interaction between Zn and Fe treatments were not significant.

Table 5: Effect of Nano-iron and Nano-zinc on the chlorophyll content in the Basil leaves (mg 100g-1 fresh weight)

Fe (mg L^{-1})	Zn (mg L^{-1})			Nano-Fe Mean Effect	Nano-Zn Mean Effect
	0	20	40		
0	9.77	11.54	12.74	11.35	13.08
30	13.44	13.90	15.07	14.14	14.00
60	16.04	16.57	14.53	15.71	14.11
LSD (0.05)	N.S			1.445	N.S

Leaves content of total soluble carbohydrates

It is noted from Table (6) that the effect of iron treatment was significant on the content of leaves of total soluble carbohydrates. The plants excelled in the T6 treatment with the carbohydrate content of the leaves, which averaged 172.4 mg g^{-1} dry matter, compared to the lowest content that resulted from the plants in the control treatment, which averaged 131.8 mg g^{-1} dry matter. Zinc treatment and the binary interaction did not significantly improve this trait.

Table 6: Effect of Nano-iron and Nano-zinc on the total soluble carbohydrates content in the Basil leaves (mg g-1 dry matter)

Fe (mg L^{-1})	Zn (mg L^{-1})			Nano-Fe Mean Effect	Nano-Zn Mean Effect
	0	20	40		
0	127.0	142.7	125.7	131.8	148.9
30	151.7	156.3	163.3	157.1	157.1
60	168.0	172.3	177.0	172.4	155.3
LSD (0.05)	N.S			11.98	N.S

Percentage of volatile oil in the leaves

Table (7) shows that the effect of spraying with iron and zinc has a significant effect on the percentage of volatile oil. The plants treated with iron in the T6 treatment gave the highest value of 10.57% compared to the lowest value of 5.91% that resulted from the control plants. Also, plants treated with T2 zinc excelled with the highest percentage of oil amounting to 9.21%, compared to the lowest content of 7.08% that resulted from plants in the Zn-free treatment. The binary interaction showed a significant superiority in this trait, as the T8 treated plants gave a percentage of oil of 11.90%, compared to the lowest percentage of oil of 4.36% recorded from the control treatment plants.

Table 7: Effect of Nano-iron and Nano-zinc on the percentage of volatile oil in the leaves (%)

Fe (mg L^{-1})	Zn (mg L^{-1})			Nano-Fe Mean Effect	Nano-Zn Mean Effect
	0	20	40		
0	4.367	6.593	6.780	5.913	7.089
30	7.433	8.017	8.963	8.138	8.318
60	9.467	10.343	11.900	10.570	9.214
LSD (0.05)	0.7118			0.4109	0.4109

It is noted from tables (2, 3 and 4) that the following studied vegetative traits (plant height, number of leaves and number of branches), and from tables (5, 6 and 7), which represented the content of leaves of total chlorophyll, soluble carbohydrates and percentage of oil, were superior by using nano-iron and nano-zinc . These characteristics increased directly with the increase in iron concentration. The reason may be attributed to the important role of iron in many physiological processes in the plant, as the increase in plant height contributed to the efficiency of the plant in absorbing water and nutrients, and that the macronutrients have an effective role in the various metabolic processes in the plant. The increase in growth reflects positively on the activity of the vegetative system, which leads to an increase in the characteristics of the vegetative system as a result of the expansion of the cells by the action of growth hormones, which leads to an increase in the number of branches and their length, as well as an increase in the number of leaves, which in turn is reflected in the other results. These results are consistent with the findings of (Al-Hiji, 2014).

As for the superiority of plants treated with zinc, the increase is due to the role of zinc, which leads to the activation and construction of the internal growth regulator indole acetic acid (IAA) and preventing its oxidation, which leads to a positive role in stimulating the growth and elongation of plant cells (Mohamed and El-Younes; 1991). In addition to being a co-factor for many important enzymes in vital processes, especially the process of photosynthesis, the processes of converting sugars into starch and the manufacture of proteins, which is reflected positively in increasing vegetative growth. Zinc also affects the building of chlorophyll pigment, which directly affects the manufacture of food needed by plants (Taiz and Zeiger; 2002). This agrees with what Muhammad (2017) concluded on the coriander plant, where he showed that zinc had a significant effect on the vegetative characteristics of the plant. Zinc also works to increase the efficiency of the photosynthesis process, which improves the characteristics of vegetative growth. Zinc also has a role in the metabolism of carbohydrates, proteins and auxins. The lack of zinc in the plant reduces the production of these substances, which reflects negatively on secondary compounds, including volatile oils (Brown et al., 1993). Zinc also affects the primary metabolic processes that ultimately lead to the biosynthesis of volatile oil (Pirzadet al., 2013), and this result is consistent with what was found by (Zahraet (2021) on the mint plant.

CONCLUSIONS

The most important conclusions reached in the experiment is that the foliar spraying of iron at concentrations of 30 and 60 mg L^{-1} and nano-zinc at concentrations of 20 and 40 mg L^{-1} had a positive effect on most of the vegetative and chemical characteristics and the percentage of oil.

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