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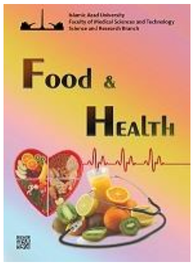

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Effect of foliar application of iron, potassium and zinc nano-chelates on nutritional value and essential oil of Basil (*Ocimum basilicum* L.)

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ABSTRACT

Basil (*Ocimum basilicum* L.) belongs to the mint family, which contains essential oils and phenolic compounds with antibacterial and antioxidant properties. Iron, potassium, and zinc are essential nutrients for plants. The use of nano-chelates is effective on vegetative characteristics essential oils percentages of medicinal plants. The aim of this study was to investigate foliar application effects of nano-chelates levels on morphophysiological and phytochemical traits of basil. This experiment was performed as a completely randomized statistical design with 10 treatments including nano-chelates of iron, potassium, and zinc (0, 2, 4, and 6 mg/l). Non-foliar treatment with nano-chelates was used as a control treatment. The results showed that foliar application of different levels of nano-chelates had a significant effect on traits such as shoot fresh weight, total chlorophyll, flavonoids, amount of iron, potassium, and zinc at the level of 1%. Also, there was a significant impact on traits such as shoot and root dry weight, root fresh weight, phenol, vitamin C and essential oil percentage at 5% level. The highest fresh and dry weight of shoots and roots, vitamin C, phenol, and zinc was observed in Zn nano-chelate treatment. The highest content of total chlorophyll, flavonoids, iron content, and essential oil content in Fe nano-chelate treatment and the highest amount of potassium was in the treatment of K nano-chelate. Foliar application of different levels of nano-chelates in basil improved quantitative qualitative and nutritional contents. Nano-chelate fertilizers affected the percentage of compounds and the amount of essential oil compounds except methyl chavicol.

1. Introduction

Basil (*Ocimum basilicum* L.) is one of the most important plants belonging to *Lamiaceae* family. Some researchers believe that basil is native to Iran, Afghanistan, and India and has long been cultivated in Egypt (1). Currently, it is mostly grown in orchards and farms in Mediterranean countries and has also been observed in semi-wild form in some areas. Fresh leaves and shoots of basil are used directly, but all parts of the fresh plant must be extracted for essential oil (2). Growth parts of basil plant contain 0.5-1% essential oil and its constituent compounds are affected by the genetic characteristics of the plant, time of harvesting and environmental factors. There are several chemicals in basil microgreens (the young seedlings of edible veggies and herbs), including citronellol and linalool, which are known to reduce inflammation in the body and even tackle bacterial infections. This makes it a great addition to your diet, especially if already suffering from aches and pains. The calcium in basil microgreens ensures that your bones and teeth will stay strong. Essential oils are composed of terpenes and polypropanoid aromatic compounds, which are derived from the Melavonic acid acetate and Shikimic acid pathways, respectively. The constituents of basil essential oil are different and several chemical types of this plant have been identified, but in general, linalool, methyl cavicol, citral, cinnamol, camphor, and methyl cinnamate are important components of its essential oil. These compounds were used in global perfume markets and the food industry. Some studies have shown that extracted polysaccharides from basil seeds consists of two main parts: glucomannan (43%), xylan

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(24.9%), and a small amount of glucan (2%) (3, 4). Today, nanotechnology is one of the new technologies that are still in its infancy. The main difference between nanotechnology and other technologies is in the scale of materials and structures used in this technology. The nano-chelates application is very diverse. Nanopowders are a mixture of particles with dimensions between 1 and 10 nm. At this scale, the physical, chemical, and biological properties of materials are quite different from those of individual atoms, molecules, or masses of matter. In fact, nanoscience affects all areas of knowledge, and agricultural science is no exception to this rule (5). One of the most important applications of nanotechnology in various fields and trends in agriculture in the soil and water sector is using nano-chelates for plant nutrition. The use of nano-chelates in order to precisely control the release of nutrients can be an effective step towards achieving sustainable and environmentally friendly agriculture (6). The most important nano-chelates used in agriculture are potassium, nitrogen, zinc and iron nano-chelates (7). Foliar application is a suitable solution to provide low-consumption nutrients such as zinc, potassium, etc. In this method, the element enters directly into the aerial part so there is no problem of turning it tends to form insoluble complexes in aerobic soils and reducing its accessibility (8). Since the most important issue of medicinal plants production is the extracted materials, determining the appropriate amount of fertilizer is important and more care should be taken in the use of chemical fertilizers. Therefore, according to the positive effect of fertilizer on quantitative and qualitative of plant's nutrition, in this study, the effect of foliar application of Fe, K, and Zn nano-chelates has been investigated in basil.

2. Materials and methods

2.1. Plant materials and experimental layout

This research was conducted in commercial greenhouses in Pakdasht County in the spring of 2020. The city of Pakdasht is located 20 kilometers east of Tehran (Lat. 51°44' N., Long 28°33' E., Elevation 960 m). The average temperature of the greenhouse was about 20 to 23°C and the light intensity was about 15 to 20 µmol/m^2/s. The available genotype seeds were obtained from Isfahan Seed Pakan Company. Seeds were sterilized for 5-7 minutes with commercial sodium hypochlorite 5% and then rinsed with distilled water. After soil testing, they were cultured in pots After seed germination, seedlings were thinned in several stages and finally, 7 plants were kept in each pot. All nanoparticles (99.8%) were purchased from Merk (Germany). They (US-Nano) were used with an average particle diameter of 10 to 30 nm. Foliar application of (2, 4, and 6 mg/l) nanoparticles were used. This research was done as a factorial experiment in a completely randomized block design with three replications. The treatments included application nano-chelates of iron, potassium, and zinc at 3 levels (2, 4, and 6 mg/l). The foliar application was applied on seedlings during 2- 4, 4-6, and 6-8 leaves stages. The pot that was not treated was considered as the control. In order to evaluate the phytochemical and morphophysiological properties of basil, sampling of traits was performed 40 days after sowing the seeds. The traits were measured as described as follows.

2.2. Observations recorded

2.2.1. Fresh and dry weight

Aerial parts in each pot were milled from the soil surface and their fresh weight was immediately measured by a digital scale with 0.01 g accuracy (9). Then the samples were kept in an oven at 40 °C and the weight was calculated with a digital scale with 0.01 g accuracy (10).

2.2.2. Chlorophyll content

3 samples were ground in 80% acetone solvent and the resulting mixture was placed at 4°C for 24 hours. The absorption is read at 645 and 663 nm (11).

2.2.3. Vitamin C

Vitamin C was measured by two-step oxidation-reduction titration. The titration operation was repeated with a solution containing 10, 20, 40, 80, 160 mg/100 ml and then the standard curve was drawn (12).

2.2.4. Phenol content

Total phenol content 0.1 mL of sample/standard solution in 5% methanol was mixed with 1 mL Folin–Ciocalteu reagent diluted with water and 1 mL 10% Na_2CO_3 was added. The absolute absorbance was taken at 760 nm (13).

2.2.5. Flavonoids content

The absorbance values of each extract solution were replaced in the rutin calibration equation, providing the content of total flavonoids expressed as rutin equivalents in mg/g DW (14).

2.2.6. Essential oils

To determine the amount of essential oil, 50 g of dried basil shoot was used after grinding. The powdered plant sample was poured into a 2 liter and 1000 ml of distilled water was added and then was connected to a Clevenger apparatus and essential oil was extracted. The amount of essential oil was expressed as a percentage (15).

2.2.7. Potassium and iron content

The samples were immediately wrapped in leaf litter and dried in an oven at 70 ° C for 48 hours. To determine the concentration of these elements, 0.1 g of the crushed samples are mixed with 10 ml of 0.1 N acetic acid and then placed in a

90 ° C pan for two hours. The samples were centrifuged at 1000 gr for 10 minutes and then the supernatant was passed through Whatman filter paper and 0.1 ml of this liquid was mixed with 1 ml of distilled water and with the atomic absorption apparatus of Flick Photometer 3100, the optimal density values of the samples are registered (16).

2.2.8. Zinc content

In this way, the plants were divided into small pieces and washed twice with ionized water; The samples were then wrapped in aluminum foil and dried in an oven for 24 hours. 1.2 g of each sample was poured into 250 ml Erlenmeyer flakes; then 25 ml of 65% HNO_3% was added to the samples. The samples were soaked in acid overnight before heating. Digestion was performed with open containers at 250°C until the liquid content of the containers evaporated and almost dried. Then 5 ml of 30% hydrogen peroxide is added to the Erlenmeyer to complete digestion and heat again until the liquid evaporates. The Erlenmeyer wall was then washed with deionized water and mixed and heated to boiling. After cooling, the contents of the containers are transferred to standard 25 ml containers and volumized with deionized water. Perkin-Elmer Model 2380 is used for the analysis of heavy metals with atomic absorption spectrometers (17).

2.3. Statistical analysis

To evaluate the normality of the distribution of the studied variables, the Kolmogorov-Smirnov test was used. The data were subjected to analyses of variance (ANOVA) using SPSS 23. Then, a means comparison was performed with Duncan's multiple test at $p < 0.05$.

3. Results

Based on Table 1, the effect of nano-chelates on shoot fresh weight, total chlorophyll, flavonoid, Fe, K, and Zn was significant at the 1% level. There is a significant statistical difference in shoot and root dry weights, root fresh weight, vitamin C and phenol content at 5%. According to Table 2, the effects of fertilizer indicated that the maximum root fresh weight, shoot dry weight and root dry weight was seen with the application of 6 mg/ l Zn nano-chelates. Comparisons of treatment marked that the highest shoot fresh weight was related to 6 mg/l Fe nano-chelates. The maximum chlorophyll content was found in Zn nano-chelates with a value of 15.21 mg/g DW and control with a value of 12.45 mg/g DW was the lowest. According to Table 2, the highest level of vitamin C was related to 6 mg/l Fe nano-chelates, and the lowest level belonged to the control plants. Among different levels of 6 mg/l zinc and potassium nano-chelates was 14.91 and 14.52 mg/100 g FW, respectively. In general, it can be said that with increasing levels of nano-chelates, the impact of nano-chelates is more effective. Foliar spray of nano-chelates (Fe, Zn, and K) enhanced phenol content in the plant. Although a change in the level of phenol was found from the lowest amount in K nano-chelates to the highest in Zn nano-chelates. Among nano-chelates treatment, 81.79 mg/g DW, 79.46 mg/l DW, and 75.12 mg/l DW are related in 6 mg/l Zn, Fe, and K nano-chelates, respectively. Flavonoids varied from the highest Fe nano-chelates (23.34 mg/g DW) to the lowest amount of in K nano-chelates (18.07 mg/g DW). The results show that the application of zinc, iron, and potassium nano-chelates improves the flavonoid content of basil so; the increasing flavonoid content is more severe than the control. The highest flavonoids of the plant among different levels of other nano-

Table 1. The effect of nano-chelates on shoot fresh weight, total chlorophyll, flavonoid, Fe, K and Zn.

SOV	df	Shoot fresh weight	Shoot dry weight	Root fresh weight	Root dry weight	Total chlorophyll	Vitamin C	Phenol	Flavonoid	Fe	K	Zn	Essential oil
Treat.	9	214.97**	135.16*	121.25*	69.28*	0.065**	3.75*	3.84*	6.78**	12.67**	43.25**	4.75**	0.025*
Error	20	12.15	9.51	8.73	2.27	0.005	0.93	0.27	0.81	0.85	1.25	1.12	0.007
CV (%)		10.25	11.86	9.45	8.54	12.50	11.25	8.95	11.34	11.12	10.76	9.15	10.67

Data showed statistical differences in studied characteristics at the level of 5 and 1%. *, **: Significant at $p<0.05$, $p<0.01$, respectively

Table 2. Effects of foliar application of nano-chelates on some morphological and biochemical traits of basil (*Ocimum basilicum* L.).

Treatments (mg/L)	Root Fresh Weight (g)	Shoot Dry Weight (g)	Shoot Fresh Weight (g)	Root Dry Weight (g)	Total Chlorophyll (mg/gFW)	vitamin C (mg/100gFW)	Phenol (mg/gDW)	Flavonoid (mg/gDW)
Control	1.05^{f}	1.27^{h}	5.80^{h}	0.05^{e}	12.4524^{g}	9.72^{h}	46.75^{g}	16.58^{g}
Nano Chelate Fe2	2.33^{e}	1.75^{g}	6.47^{f}	0.12^{d}	13.9612^{de}	11.32^{f}	59.34^{de}	18.92^{e}
Nano Chelate Fe4	2.43^{de}	2.23^{ef}	8.02^{cd}	0.19^{bc}	14.5681^{c}	13.79^{c}	65.07^{cd}	19.89^{d}
Nano Chelate Fe6	2.68^{d}	3.41^{b}	9.87^{a}	0.24^{ab}	15.5026^{a}	15.44^{a}	79.46^{a}	23.34^{a}
Nano Chelate K2	2.49^{de}	2.11^{f}	6.70^{ef}	0.15^{c}	13.0813^{f}	10.63^{g}	56.32^{e}	18.07^{f}
Nano Chelate K4	3.20^{c}	2.85^{d}	7.35^{e}	0.18^{bc}	14.2775^{cd}	12.48^{de}	61.74^{d}	19.16^{de}
Nano Chelate K6	3.42^{bc}	3.75^{a}	8.42^{c}	0.22^{b}	14.9578^{bc}	14.52^{bc}	75.12^{b}	22.27^{b}
Nano Chelate Zn2	3.27^{c}	2.45^{e}	6.10^{g}	0.17^{bc}	13.6562^{e}	11.98^{e}	51.27^{f}	18.41^{f}
Nano Chelate Zn4	3.42^{bc}	3.21^{c}	7.86^{d}	0.21^{b}	14.2467^{d}	13.12^{d}	67.56^{c}	20.82^{c}
Nano Chelate Zn6	4.02^{a*}	3.81^{a}	9.12^{b}	0.27^{a}	15.2105^{b}	14.91^{b}	81.79^{a}	22.96^{ab}

*Means followed by the same letter are not different according to the Duncan test at 1 and 5 %.

chelates were seen in the treatment of Zn at 6 mg/l (23.34 mg/g DW) and K at 6 mg /l (22.27 mg/g DW). The results of this study showed that foliar application with different levels of Fe, K, and Zn play a crucial role in morphological and biochemical features. Foliar application of 6 mg/l Fe yielded the highest amount of chlorophyll, vitamin-C, flavonoid, shoot fresh weight. Also, nano-chelates that mostly were sprayed with 6 mg/l Zn have been indicated to improve the fresh/dry root weight, phenol, and Zn content. Application of 6 mg/l K nano-chelates treatment can improve potassium rate. The results indicated that the application of Fe nano-chelates may increase the iron content of basil. The maximum iron was seen in 6 mg/l Fe nano-chelates (81.82 mg/g DW); the lowest level was related to the control (67.81 mg/g DW) (Fig. 1). Based on the registered results (Fig. 2), the greatest average potassium was obtained in 6 mg/l K nano-chelates with 153.12 mg/g DW, and control with 114.33 mg/g DW was the lowest amount.

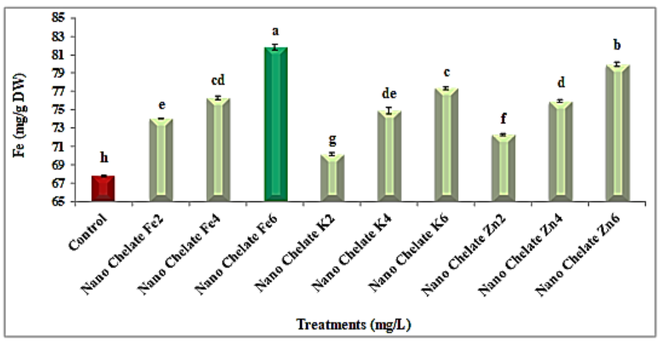

Fig. 1. Effects of foliar application of nano-chelates on Fe content in basil (*Ocimum basilicum* L.). Values are mean±SD. Values marked by different letters are significantly different ($p<0.05$).

The result indicated that Zn nano-chelates had the maximum Zinc level (4.81 mg/g) and the control remarked the least content (5.35 mg/g DW) (Fig. 3). Our finding demonstrated K nano-chelates 6 mg/l recorded the maximum essential oil content was which not significant difference with Fe and Zn 6 mg/l (Fig. 4).

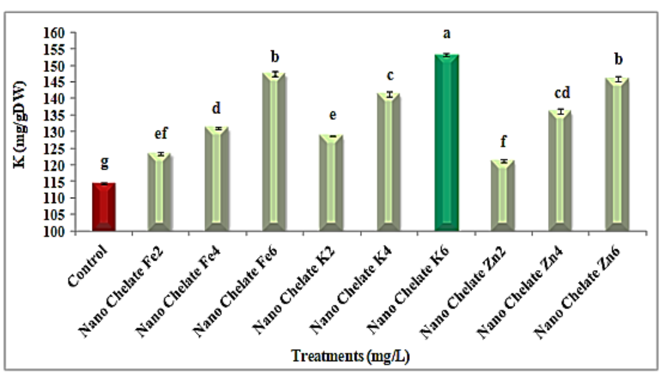

Fig. 2. Effects of foliar application of nano-chelates on potassium content of basil (*Ocimum basilicum* L.). Values are mean±SD. Values marked by different letters are significantly different ($p<0.05$).

The identified compounds and their percentages at different levels of iron, potassium, and zinc nano-chelates are shown in Table 3. A total of 28 components in essential oil were observed in the control treatment. Application of nano-chelates showed that 15 compounds were obtained in Zn Nano-chelates treatment, 10 compounds in iron, and 13 compounds in potassium treatment. Based on the observed results, it can be stated that nano-chelates affected the amounts of compounds except for methyl chavicol which has been decreased. The highest compounds except methyl chavicol were found at the levels of 6 mg/ g of nano-chelates.

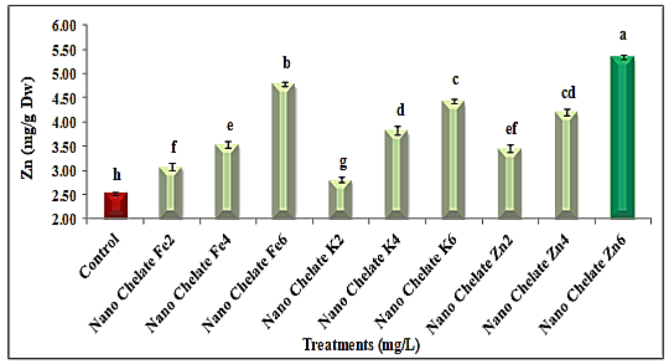

Fig. 3. Effects of foliar application of nano-chelates on Zinc content of basil (*Ocimum basilicum* L.). Values are mean±SD. Values marked by different letters are significantly different ($p< 0.05$).

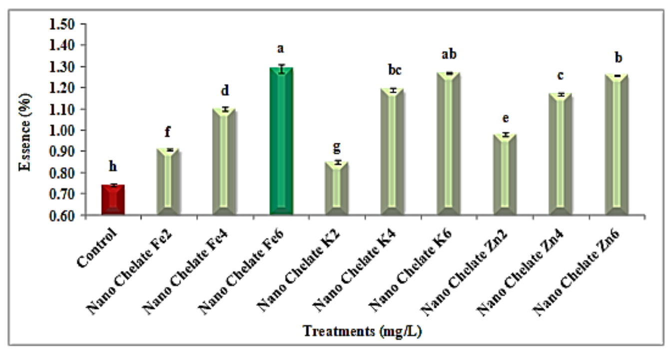

Fig 4. Effects of foliar application of nano-chelates on essential oil in basil (*Ocimum basilicum* L.). Values are mean±SD. Values marked by different letters are significantly different ($p<0.05$).

4. Discussion

The results in this study showed that the shoot and root weight of the plant is directly related to different levels of Fe, K and Zn nano-chelates. In agreement with these results, it can be said that the role of iron as a catalyst in the respiration process has been proved, so the application of Fe nano-chelates can be effective in the production of secondary metabolites and plant growth. Also, since it is affecting the chlorophyll content; the increasing trend of shoot fresh weight due to the application of nano-chelates is logical (18, 19). It can be stated that potassium is necessary for the synthesis and nutrient transportation in the plant and helps to eliminate adverse effects of some plant nutrients in the soil and is also effective in regulating water uptake activity. Potassium as an active element in many important metabolic processes in plants that is important for transportation in the phloem, osmotic balance, and photosynthesis; (20) Therefore, the presence of this element due to potassium nano-chelates increases growth and leads to more weight gain of shoots. In addition, zinc has a significant impact on various enzymatic systems and zinc deficiency in the plant has caused the inefficiency of these systems and as a result has led to the reduced growth of young leaves and germination, which in turn declined the weight. Our obtained results were agreed with (21), which found that the highest fresh and weight of shoots was related to the normal irrigation and foliar application. In our research iron and potassium, nano-chelates enhanced the amount of phenol and flavonoids in the treated plant. Flavonoids are secondary metabolites that, due to their defense mechanism, protect plants from pathogens and insects. Phenols and flavonoids have antioxidant properties and are involved in the regulation of enzymatic activities and the production of primary metabolites (19). Foliar application of nano-chelates can affect plant phenols and flavonoids by activating enzymes involved in starch and protein biosynthesis in the synthesis of secondary compounds. Potassium also increases carbohydrates in the plant, so that wherever there are more carbohydrates, phenolic compounds enhance. The maximum application of zinc nano-fertilizer leads to a higher amount of phenol and flavonoids, which have a positive correlation between the amount of phenol and flavonoids with antioxidants and the increase in antioxidants due to the presence of zinc nano-chelates. In the study of (22), the treatment of plants with different concentrations of nanosilicon controlled the reduction of phenol in salinity conditions. The application of iron fertilizers increased the flavonoids content of *Ocimum basilicum* L which are according to (23) in grapes. By increasing the amount of K nano-fertilizer; total phenol levels were also enhanced, which is matching with the study of (24, 25, 26). Increasing the amount of zinc nano-fertilizer lead to expanding the total

Table 3. Foliar application effects of nano-chelates on essential oil composition in basil (*Ocimum basilicum* L.).

Nano Chelate Zn6	Nano Chelate Zn4	Nano Chelate Zn2	Nano Chelate K6	Nano Chelate K4	Nano Chelate K2	Nano Chelate Fe6	Nano Chelate Fe4	Nano Chelate Fe2	Control	Inhibition index	Type of composition
0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	939	α-Pinene
1.4	1.2	1.2	1.4	1.5	1.2	-	-	-	0.9	975	Sabinene
0.35	0.4	0.3	0.4	0.3	0.4	-	-	-	0.3	989	Myrcene
2.3	2.1	1.8	-	-	-	-	-	-	1.8	1030	1,8-Cineol
20.12	19.95	19.75	17.56	17.25	17.14	-	-	-	17.5	1088	Linalool
3.2	3.3	2.9	2.5	2.6	2.4	-	-	-	2.3	1355	Eugenol
0.9	0.7	0.8	-	-	-	-	-	-	0.7	1145	Camphor
0.2	0.3	0.2	-	-	-	-	-	-	0.3	1177	Terpinen-4-ol
2.8	2.9	3.2	-	-	-	-	-	-	1.8	1188	α-Terpineol
1.2	0.9	0.8	-	-	-	-	-	-	0.5	1229	Cis-Carveol
0.6	0.7	0.6	0.4	0.3	0.4	2.1	1.4	1.1	0.4	1265	Geraniol
4.81	4.7	4.5	-	-	-	-	-	-	3.8	1511	Cubenol
1.84	1.75	1.54	-	-	-	-	-	-	1.4	1642	Epi-α-Muurolol
3.6	3.3	3.4	-	-	-	-	-	-	2.1	1045	E-ß-Ocimene
20.35	20.12	19.65	-	-	-	-	-	-	17.5	1243	Carvone
-	-	-	0.2	0.1	0.2	0.2	0.2	0.1	0.2	987	6-Methyl-5-hepten-2-one
-	-	-	11.75	11.85	12.2	11.86	11.89	12.3	12.5	1196	Methyl Chavico
-	-	-	0.8	0.7	0.9	1.1	1.2	0.9	0.6	1230	Nerol
-	-	-	-	-	-	1.1	0.9	0.95	0.6	1242	Neral
-	-	-	-	-	-	11.98	11.84	11.73	11.5	1456	A-Humulene
-	-	-	-	-	-	0.8	0.9	0.7	0.3	1213	Actanol acetate
-	-	-	-	-	-	0.9	0.9	0.8	0.8	980	1-Octen-3-ol
-	-	-	-	-	-	8.95	8.9	8.5	8.5	1272	Geranial
-	-	-	-	-	-	-	-	-	0.65	1418	E-Caryophyllene
-	-	-	0.15	0.11	0.8	-	-	-	0.8	1150	Isopulegol
-	-	-	0.14	0.12	0.9	-	-	-	0.6	1537	Italicence ether
-	-	-	3.2	2.7	2.1	-	-	-	1.4	979	ß-Pinene
-	-	-	6.8	6.5	6.2	-	-	-	5.3	1171	Menthol

phenol rate which is in line with (27, 28). Nano-chelates- foliar application of iron fertilizers produce much flavonoid content of basil. These obtained results are in accordance with (29). The reason for the increasing iron and potassium trend can be stated that enhancing the application of iron nano-chelates, in a certain area that transfers to the plant is associated with more iron uptake from the soil and increases the uptake of this element in the plant. Also, potassium depletion reduces soil water, which leads to a reduction in the flow of elements from the soil to the plant. Foliar application of potassium nano-chelates due to the fact that it contains appropriate amounts of potassium in the form of nano-chelates foliar nutrition; increases the absorption and accumulation of potassium in various organs of the plant. In general, high K nano-chelates levels had a positive impact on basil which is similar to (30, 31). Moreover, Zn-Fertilizer application 6 mg/l plays a pivotal role in increasing the basil zinc content which consists of basil. (30) Additionally, the maximum amount of iron and potassium content was observed in the treatment of 6 mg/l Fe and K nano-chelates, in fenugreek, respectively by (32). Vitamin C is a small water-soluble antioxidant molecule that acts as a primary substrate in cyclic pathways to detoxify hydrogen peroxide. Potassium, by having a molecular charge and binding to membranes, stabilizes them, thereby preventing the binding of free radicals and reactive oxygen species to the membrane and helping to maintain the health of biological membranes (33). In fact, the role of antioxidants such as vitamin C takes over and prevents the breakdown of vitamins and increases them in the plant. Consistent results have been obtained by (34**).** There was a significant difference between the Zn and K foliar application treatments in terms of vitamin C that are in line with (35). According to mean comparisons, Zn nano-chelates levels led to increased it in the plant that is in conformity with (36). Due to the fact that iron has a great effect on plant growth and development, one of the reasons for increasing the photosynthetic activity of the plant can be considered the role of this element in the activity of chloroplasts, which leads to more production of essential secreting in leaves (22). It is in line with (22) that found nanosilicon treatment had the greatest effect on improving chlorophyll content in peppermint. The highest of total chlorophyll of pot marigold leaves was related to normal irrigation and foliar application of proline (37). The maximum rate of total chlorophyll and ascorbic acid was seen in the treatment of iron nano-chelates 6 mg/l, respectively, in savory and parsley, respectively (22). It seems that micronutrients, especially potassium, increase plant yield and essential oil through their effect on plant dry matter. Microelements increase the number of leaves and the amount of essential oils of medicinal plants, which may be due to the fact that the use of potassium and zinc while expanding the leaf surface, increases the number of secreted tissues by the essential oil in the leaves. The data revealed that essential oil percentage increased with increasing doses of nano-chelates. The highest percentages of essential oils with 1.75% were found in the treatment of nanosilicon by (22). The major compounds identified at different levels of nitrogen fertilizers include methyl chavico, Linaloolt, Eugenol, Menthol, Geranial and Italicene. The mean percentage of these compounds was higher in nano-chelates treatments with higher levels than the control treatment which are in congruence with the results obtained from (38) in basil. Iron nano-chelates are expected to increase Fe in the plant. In the analysis of essential oil analysis results, it was observed that using Iron nano-chelates in basil; methyl chavicol (37.8-43.9), neral (22.6-20.5), nerol (1.5-2.7), Geranial (25.1-21.6), octanol acetate (0.7-1.2), α-humulene (0.4-0.9) were the main components identified in essential oil and with increasing the level of nano-iron fertilizer, the amount of these compounds enhanced, indicating the positive effect of nano-chelates on basil essential oils. These results are corresponded with (6). Foliar application of different levels of potassium nanofertilizer has an impact on essential oil (30). In reviewing the results of essential oil analysis, it was observed that using potassium nano-chelates in basil; Linalool (17.34-17.66), methyl chavicol (11.87-12.3), Menthol (6.3-6.93), Sabinene (1.2-1.4) were the important composition recognized in the essential oil. The amount of these compounds increased with increasing the level of Fe nano-chelates, which indicates the positive effect of Fe nano-chelates on the essential oil of basil. Different levels of Zn nano-chelates improved essential oil content in treated plants Linalool (42.2-46.2), 1,8-Cineol 1.9-2.2), Eugenol (5.9-6.91), a-terpineol (7.3-5.4), epi-α-muurolol (2.5-3.9), E-β-ocimene (2.2-3.8) and Carvone (18.8-20.84) were the major compounds. In similar studies, the use of zinc has more or less caused changes in the components of the essential oil. Researchers observed that zinc application increased the concentration of menthol in Japanese peppermint essential oil. A previous study **(**39**)** reported that foliar application of zinc sulfate increased the predominant component of cumin aldehyde in the essential oil of the seed and vegetative tissue of *Cuminum cyminum*. However, the results of (40) in *Matricaria chamomilla* showed that zinc soil application was slightly affected on major essential oil compounds such as camazoline and beta-farnesene. Also, some researchers (28) mentioned that consumption of zinc sulfate (soil and leaf) increased the predominant component of carvone in *Tanacetum balsamita*. The results showed that the interaction of iron and zinc elements on leaf chlorophyll content, number of seeds per plant, biological yield, and grain yield was significant and the highest essential oil yield was obtained from plants treated with iron 6 per thousand and zinc 4 /1000. The lowest essential oil yield was related to foliar plants with a concentration of 2 /1000 iron and zinc. According to (41) findings, it seems that the treatment of basil leads to enhancing the nutritional value of basil in response to the conjugation of these exogenous fertilizer. Previous study demonstrated that the content of monoterpenoids (geraninal, eugenol, β-cubebene, trans-α-bergamotene, germacrene D, methyl chavicol and (E)-caryophyllene) and sesquiterpenes (E)-γ-bisabolene) in sweet basil oil was influenced by biochar and Potassium-Nano Chelate, significantly (42). Nano-iron chelated increased the activity of these enzymes. It can be concluded that higher densities of bio-simulative methanol and Nano-iron chelated increased essential oil, methyl-cahvicol and some other affective enzymes which decrease induced environmental stresses. Although, higher densities of them would decrease biosynthesis of neral and neryl formate (1). The application of Fe nano-complexes significantly increased the occurrence and concentration of sesquiterpenes, while decreasing the content of oxygenated monoterpenes Please revise the conclusion (43).

5. Conclusion

In general, studying the amount and composition of secondary plant metabolites, particularly essential oils of plants, is an attractive research area that needs further studies under different conditions e.g., different sources and levels of Nano-chelate fertilizers. Our findings demonstrate that the content of essential oil and phytochemical traits such as total chlorophyll, flavonoids, amount of iron, potassium, phenol, flavonoid, and nutritional contents in basil was affected by iron**,** potassium, and zinc nano-chelates, significantly, and this plant is very promising for use in the folk medicines. Nano-chelates affected the percentage of compounds and the amounts of compounds except for methyl chavicol.

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