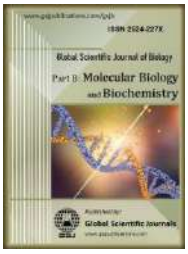
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Content of Some Mineral Elements (N, Ph, K, Ca, Mg, Zn) of the Chamomile Plant (Chamomilla Recutita L.) under the Influence of Selenium and Zinc and their Interactions

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ABSTRACT

The aim of this experiment was to determine the role of selenium and zinc and their interaction in stimulating certain chemical properties of chamomile. Three concentrations of selenium (0.010, and 0.020 mg L^{-1}) and four concentrations of zinc (0, 0.025, 0.050, and 0.0100 mg L^{-1}) were used to investigate the effects of these elements on the nitrogen, potassium, phosphorus, magnesium, calcium, and zinc content of chamomile. The experiment was conducted using a completely randomized block design with three replicates, resulting in 36 experimental units. The results showed the following:

- Both selenium and zinc had a positive effect.
- High concentrations of both elements contributed to increased performance across all these traits.
- The interaction between high concentrations of selenium and zinc and high-concentration spraying had a positive effect.

1. Introduction

Chamomile, belonging to the Asteraceae family, is considered the king of medicinal and aromatic plants and a primary source for obtaining medicines from its isolated biologically active compounds (Maqbool & Al-Sakit, 1995). It is an annual herb with an erect, highly branched stem that grows to a height of 10-80 cm. It has a smooth, multi-branched trunk, long, narrow, light green leaves, short but widespread roots, and heterogeneous flowers. The fruit is a yellowish-brown canker (Singh et al., 2011).

The active part is the flowers, which contain the volatile essential oil that evaporates upon exposure to air and has a strong aromatic scent. This oil is extracted from chamomile flowers at a concentration of 0.5–1% (Moussa et al., 2010). The active compound in the oil is chamazulene (blue), which is extracted using steam distillation. Chamomile oil is a thick, viscous, blue liquid that solidifies at 5°C and has the same aroma as chamomile. (Budzinski et al., 2000). Chamomile is an important herb in traditional medicine,. It holds

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significant economic value due to its numerous health benefits, both traditional and modern, stemming from its unique compounds, most notably coumarins, flavonoids, terpenes, effective oils, polysaccharides, and others. These materials are known for their anti-cancer, anti-clotting, anti-infective and anti-depressant. They also help lower pressure , cholesterol, and offer neuroprotective benefits ,

The best form for absorption of the element is in the ionic form of selenite (SeO3-2) or selenate (SeO4-2), as it accumulates in these two forms in the plant to higher concentrations than what is present in the medium or soil, and it spreads in the plant faster than any other form of selenium (Dai et al., 2023). Selenium is one of the most powerful antioxidants and acts as a cofactor in the enzyme antioxidant system, particularly glutathione peroxidase (Alazzawi and Faisal, 2015)., particularly glutathione peroxidase (Alazzawi and Faisal, 2015). Recent experiments have proven its high efficiency in inhibiting tumors and its anti-cancer properties, and that its deficiency in the human body leads to heart muscle failure and the occurrence of angina and strokes (Abdul Wahid et al., 2014). Selenium helps to neutralize free radicals (Pal *et al*., 2013) . Selenium binds to amino acids and proteins and forms special proteins called Seleno-proteins. It binds to the coenzyme Ubiquinol, also known as Q-10, to become an anti-cancer and tumor-preventing agent. Selenium is now produced as an anti-cancer drug (Cruz et al., 2016).

Selenium is a key nutrient for animals and flowering plants; certain plants have the ability to accumulate it and convert it into biologically active compounds. Selenium is a key nutrient for animals and flowering plants; certain plants have the ability to accumulate it and convert it into biologically active compounds. The concentration of selenium in plant tissues depends on its levels in the soil, with grains being among the agricultural products richest in this element. It is essential for the human body, regulating vital processes .

Selenium is frequently associated with the amino acids selenomethionine and selenocysteine forms in which a selenium atom replaces the sulfur atom and acts as a potent antioxidant that protects cell membranes and enzymes (Elwakil & Elwakil, 2020).

Treating plants with selenium has been shown to enhance growth and plant characteristics (Abdul-Razzaq, 2023) and increase the dry weight of the shoot (Al-Tamimi, 2018). Zinc is an important nutrient involved in many enzyme systems that regulate various metabolic reactions. It is also essential for the formation of auxins and proteins and for accelerating seed maturation (Solanki, 2017). Zinc activates the synthesis of tryptophan, which is the building block for auxin synthesis. It also stimulates the enzymes carbonic peptidase, proteinase, and anhydrase, thus playing a role in protein and starch synthesis. Furthermore, it stimulates the synthesis of cytochrome b, cytochrome a, and cytochrome oxidase, and maintains the stability of ribosome components (Verma and Verma, 2010). Metabolic pathways, such as photosynthesis, respiration, lipid oxidation, and aging, have byproducts in the form of increased free radicals, which oxidize plant cells, particularly in organelles where electron transfer occurs, such as chloroplasts and mitochondria, causing oxidative damage (Becana et al., 2000). Zinc is located in the third period of the periodic table (period 1 transition), under group BII, which also includes cadmium and mercury. Its concentration in the Earth's crust is 70 mg/kg^{-1} of soil, and its ionic radius is 0.74 angstroms, similar to magnesium (Juillot et al., 2008). It is important in the metabolism of RNA and DNA, as well as contributing to chlorophyll formation, which is due to its direct effect on amino acid and protein synthesis (Brian, 2008 Zinc (Zn) is a micronutrient that influences many physiological and biochemical metabolic pathways. (Hamza et al., 2022). Treating plants with zinc has a significant impact on their growth characteristics (Badriet et al., 2026). The research investigated the effect of treatment with selenium and zinc, and their interaction with each other, on some micro- and macro-elements of the chamomile plant..

2. Materials and Methods

The field experiment was conducted during the 2025-2026 agricultural growing season, in the Latifiya area, which belongs to the Mahmudiya district within the Baghdad Governorate, in order

to determine the role of the elements selenium and zinc and their interaction with some of the micro and macro elements of the chamomile plant. Chamomilla recutita L.). The field was prepared by plowing the experimental plot twice with a mechanical plow, then harrowing and fertilizing by adding Diaminophosphate (DAP) fertilizer to all experimental units.

The experiment included two factors:

- Selenium concentrations (0.01 gm.L, 0.02 gm.L, and control.(
- Zinc concentrations (0.025 gm.L, 0.050 gm.L, and 0. 100 gm.L, and control.(
- The experiment was designed as a Randomized Complete Block Design (RCBD) as a factorial experiment (3×4×3). The experiment was divided into three replicates, each containing 12 experimental units.

Determination of elements.

Digestion of plant samples

The digestion process was carried out as described in the method of (Haynes, 1980). (Haines, 1980); oven-dried samples (dried for 80 days) were used, with an initial mass of 0.2 g of ground tissue. A 1:4 mixture of sulfuric and perchloric acids was employed, and the sample was heated to digest the elements; The sample was heated and a clear, ready-to-use digestion solution was produced.

measuring nitrogen content (mg plant^{-1}).

Nitrogen concentration in the vegetative parts was first determined from samples digested using the Kjeldahl method (Chapman and Pratt, 1961); the total content of nitrogen was then calculated by multiplying the resulting nitrogen concentration by the plant's dry weight.

Determination of total phosphorus content (mg plant^{-1}).

Phosphorus concentration was determined using the method of(Matt, 1970) via a spectrophotometer at a wavelength of 882 nm, the total content phosphorus was then computed by multiplying the resulting phosphorus concentration by the plant's dry weight.

Determination of total potassium content (mg plant^{-1}).

The potassium concentration in the vegetative part of the sample was first measured using an special absorption spectrometer, following the method of(Chapman and Pratt, 1961); the total potassium content was then computed by multiplying the resulting potassium concentration by the plant's dry weight.

Determination of total calcium content (mg plant^{-1}).

Calcium concentration was first determined in digested samples of the plant's vegetative parts using the method of (Wimberly, 1968) and an Special absorption spectrometer; the total calcium content was then calculated by multiplying the resulting calcium concentration by the plant's dry weight.

Determination of total magnesium content (mg·plant^{-1}).

Magnesium concentration in digested samples was measured using an atomic absorption spectrophotometer according to the method of (Wimberly, 1968). The total magnesium content was then calculated by multiplying the resulting magnesium concentration by the plant's dry weight.

Determination of zinc content (µg plant^{-1}).

Zinc content in the digested shoot samples was determined according to the method of (Allan 1961) using an atomic absorption spectrophotometer.

Statistical examination.

The SAS (Statistical examination System, 2012) software was used to analyze the data based on a 3×4×3 factorial experiment, employing a Randomized Complete Block Design (RCBD) to examine the effects of the various factors on the studied traits. The arithmetic means were

compared to reveal the significance of the differences, using the least significant difference.

3. Results and Discussion

The data in Table (1) showed that demonstrated a significant effect of increasing selenium concentrations on increasing nitrogen content. The highest mean value was 127.85 mg·plant^{-1} at a selenium concentration of 0.02 gm·L^{-1}, while the lowest mean value was 96.81 mg·plant^{-1} at a selenium concentration of zero.

The same table indicates a significant effect of zinc on increasing nitrogen content; as the zinc concentration was raised from 0 to 0.100 gm·L^{-1}, the mean concentration increased from 95.95 to 125.31 mg plant^{-1}. Results regarding the interaction between selenium and zinc concentrations showed significant differences in nitrogen content; the highest value 146.38 mg plant^{-1} was observed at concentrations of 0.020 gm·L^{-1}selenium and 0.100 gm·L^{-1}zinc, while the lowest value 87.45 mg plant^{-1} was recorded at zero concentration for both elements.

Table (1) Nitrogen chamomile plant under the influence of selenium and zinc and their interactions(mg.plant-1)

Selenium concentrations gm·L^{-1}	**Zinc concentrations** gm·L^{-1}				Average
	0	**0.025**	**0.050**	**0.100**	
0	**87.45**	**94.21**	**99.59**	**106.00**	**96.81**
0.010	**92.21**	**109.27**	**114.94**	**123.56**	**109.99**
0.020	**108.18**	**121.01**	**135.84**	**146.38**	**127.85**
	السيلينيوم × الزنك = 1.86				**Selenium effect = 0.92**
average	**95.95**	**108.16**	**116.79**	**125.31**	
L.S.D (0.05)	**Zinc effect = 1.02**				

The data in Table (2) showed thatdemonstrated a significant effect of increasing selenium concentrations on increasing phosphorus content; the highest mean value was 34.80 mg·plant^{-1} at a selenium concentration of 0.02 gm·L^{-1}, while the lowest mean value was 25.55 mg·plant^{-1} at a selenium concentration of zero.

The same table indicated a significant effect of zinc on increasing phosphorus content; as the zinc concentration was raised from 0 to 0.100 mg L^{-1}, the mean concentration increased from 25.07 to 35.52 mg plant^{-1}.

The results in Table (2) regarding the interaction between selenium and zinc concentrations revealed significant differences in phosphorus content. The highest value 39.15 mg plant^{-1} was observed at concentrations of 0.020 mg L^{-1} selenium and 0.100 gm·L^{-1}zinc, whereas the lowest value 20.68 mg plant^{-1} was recorded at zero concentrations of both selenium and zinc.

Table (2) Phosphorus chamomile plant under the influence of selenium and zinc and their interactions(mg.plant-1)

Selenium concentrations gm·L^{-1}	**Zinc concentrations** gm·L^{-1}				average
	0	**0.025**	**0.050**	**0.100**	
0	**20.68**	**23.41**	**27.90**	**30.21**	**25.55**
0.010	**24.80**	**28.58**	**35.10**	**37.19**	**31.42**
0.020	**29.73**	**34.19**	**36.14**	**39.15**	**34.80**
L.S.D (0.05)	**Selenium × Zinc = 3.09**				**Selenium effect = 1.48**
average	**25.07**	**28.73**	**33.05**	**35.52**	
L.S.D (0.05)	**Zinc effect = 1.52**				

The data in Table (3) showed thatdemonstrated a significant effect of increasing selenium concentrations on increasing potassium content; the highest mean value was 76.00 mg/plant at a selenium concentration of 0.02 gm·L^{-1}, while the lowest mean value was 58.38 mg/plant at a concentration of 0 gm·L^{-1}. The same table indicated a significant effect of zinc on increasing potassium content; increasing the zinc concentration from 0 to 0.100 gm·L^{-1}resulted in a rise in the mean concentration from 55.61 to 78.07 mg/plant.

The data in Table (3) showed that regarding the interaction between selenium and zinc concentrations revealed significant differences in the increase of potassium content. The highest value 87.54 mg/plant was observed at concentrations of 0.02 gm·L^{-1}selenium and 0.100 gm·L^{-1} zinc, whereas the lowest value 48.61 mg/plant was recorded at zero concentrations of both selenium and zinc.

Table (3) potassium chamomile plant under the influence of selenium and zinc and their interactions(mg.plant-1)

Selenium concentrations gm·L^{-1}	**Zinc concentrations** gm·L^{-1}				average
	0	**0.025**	**0.050**	**0.100**	
0	**48.61**	**55.32**	**60.48**	**69.10**	**58.38**
0.010	**54.01**	**63.48**	**69.82**	**77.57**	**66.22**
0.020	**64.21**	**70.19**	**82.04**	**87.54**	**76.00**
السيلينيوم × الزنك = 3.32	**السيلينيوم × الزنك = 3.32**				**Selenium effect = 1.32**
average	**55.61**	**63.00**	**70.78**	**78.07**	
L.S.D (0.05)	**Zinc effect = 1.87**				

The data in Table (4) showed thatdemonstrated the significant effect of increasing selenium concentrations on raising calcium content; the highest mean value was 113.02 mg/plant at a selenium concentration of 0.02 gm·L^{-1}, while the lowest mean value was 93.44 mg/plant at a concentration of 0.

The same table also shows a significant effect of zinc on increasing calcium content. When the zinc concentration was increased from zero to 0.100 gm·L^{-1}, the average concentration increased from 86.54 to 118.47 gm•L^{-1} .

The table results for the binary interaction between selenium and zinc concentrations showed significant differences in increasing calcium content. The highest value was observed at concentrations of 0.02 and 0.100 gm·L^{-1}of selenium and zinc, reaching 127.54 gm·L^{-1}. The lowest value was 77.45 gm·L^{-1}at zero concentration of selenium and zinc.

Table (4) Calcium chamomile plant under the influence of selenium and zinc and their interactions(mg·plant-1)

Selenium concentrations gm·L^{-1}	**Zinc concentrations** gm·L^{-1}				average
	0	**0.025**	**0.050**	**0.100**	
0	**77.45**	**89.21**	**98.70**	**108.38**	**93.44**
0.010	**89.62**	**103.84**	**112.15**	**119.49**	**106.28**
0.020	**92.54**	**109.39**	**122.61**	**127.54**	**113.02**
	السيلينيوم × الزنك = 2.11				**Selenium effect = 1.09**
average	**86.54**	**100.81**	**111.15**	**118.47**	
L.S.D (0.05)	**Zinc effect = 1.38**				

Table (5) shows the significant effect of increasing selenium concentrations on increasing magnesium content. The highest average was 86.35 gm.L^{-1} at a selenium concentration of 20 gm.L^{-1} , and the lowest average was 73.29 gm.L^{-1} at a selenium concentration of zero.

The same table also shows a significant effect of zinc on increasing magnesium content. When the zinc concentration was increased from zero to 0.100 gm·L^{-1}, the average concentration increased from 69.88 to 90.96 gm.L^{-1}. The table results for the binary interaction between selenium and zinc concentrations showed significant differences in increasing magnesium content. The highest value was observed at concentrations of 0.02 and 0.100 gm·L^{-1}of selenium and zinc, reaching 97.86 gm·L^{-1} . The lowest value was 62.12 gm·L^{-1} at zero concentration of selenium and zinc.

Table (5) Magnesium chamomile plant under the influence of selenium and zinc and their interactions(mg.plant-1)

Selenium concentrations gm·L^{-1}	**Zinc concentrations** gm·L^{-1}				average
	0	**0.025**	**0.050**	**0.100**	
0	**62.12**	**69.62**	**76.17**	**85.25**	**73.29**
0.010	**70.42**	**75.22**	**86.19**	**89.76**	**80.40**
0.020	**77.11**	**83.85**	**86.57**	**97.86**	**86.35**
2.23 = السيلينيوم × الزنك	**2.23 = السيلينيوم × الزنك**				**Selenium effect = 1.14**
average	**69.88**	**76.23**	**82.98**	**90.96**	
L.S.D (0.05)	**Zinc effect = 1.21**				

Table (6) shows the significant effect of increasing selenium concentrations on increasing zinc content. The highest average was 93.81 µg/L at a selenium concentration of 0.02 gm·L^{-1}, and the lowest average was 87.79 µg/L at a selenium concentration of zero. The same table also shows a significant effect of zinc on increasing zinc content. When the zinc concentration was raised from zero to 0.100 gm·L^{-1}, the average concentration increased from 84.63 to 96.66 µg/L. Table (6) shows the results of the binary interaction between selenium and zinc concentrations, revealing significant differences in zinc content. The highest value was observed at concentrations of 0.02 and 0.100 gm·L^{-1} of selenium and zinc, respectively, reaching 99.12 µg/L. The lowest value was 81.41 µg/L at zero concentration of selenium and zinc.

Table (6) Zinc chamomile plant under the influence of selenium and zinc and their interactions(mg.plant-1)

Selenium concentrations $gm \cdot L^{-1}$	**Zinc concentrations** $gm \cdot L^{-1}$				average
	0	**0.025**	**0.050**	**0.100**	
0	**81.41**	**85.82**	**89.90**	**94.01**	**87.79**
0.010	**84.37**	**87.91**	**93.14**	**96.86**	**90.57**
0.020	**88.10**	**89.21**	**98.80**	**99.12**	**93.81**
L.S.D (0.05)	**Selenium × Zinc = 2.93**				**Selenium effect =1.52**
average	**84.63**	**87.65**	**93.95**	**96.66**	
L.S.D (0.05)	**Zinc effect = 1.99**				

The increase recorded in the rates and values of the studied traits is due to the action of selenium in increasing root growth, increasing the formation and emergence of adventitious roots, and increasing the absorption area of nutrients, especially NPK. (Abul-Soud and Abd-Elrahman, 2016) Selenium is believed to bind to amino acids to form Seleno-amino acid, which protects amino acids from breakdown. It is also believed to enter into the structure of glycine betaine, which increases the osmotic pressure of root cells when it is transferred to them, drawing water and nutrients from the external environment for the benefit of the plant's root cells (Manaf, 2016). It is also believed that the increased absorption of elements is due to selenium's action in preventing the oxidation of cytochromes, which play a role through the cytochrome pump in the absorption of salts (Li et al, 2025). The above-mentioned properties were enhanced as a result of zinc application, which affects plasma membrane integrity by binding to SH groups of the membrane's protein segment, thus increasing its stability and permeability. This, in turn, enhances its ability to absorb essential nutrients (Ying et al., 2025). Zinc is important in the transport of soluble nitrogen-containing compounds such as amides and amino acids between leaves, fruits, and roots, which are a source of nitrogen and carbon for building most of the by-products such as phenolic acids and plant alkaloids. It also stimulates the enzyme responsible for converting glutamic acid to alpha-ketoglutaric acid in the reactions of the citric acid cycle (Tóth and Makoena, 2025). It also contributes to photosynthesis by stimulating the formation of both Enolase and Aldolase enzymes, which are effective in the formation of carbohydrate breakdown compounds and enzymes, thus releasing the energy necessary for metabolic processes, such as active transport and absorption of elements whose absorption depends on the presence of energy. It stimulates the oxidation enzyme in the electron transport chain stage, Cytochrome oxidase, and stimulates the building of ion-carrying proteins, namely Cytochromes, which increases the entry of negative ions, including the phosphate ion PO4 (Yassin, 2001). It is also believed that the increased absorption of elements is due to the role of selenium as an antioxidant, preventing the oxidation of cytochromes, which play a role through the cytochrome pump in the absorption of salts (Li et al, 2025).

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