Effect of application potassium silicate K_2siO_3 and Calcium oxide CaO on vegetative and chemical characteristics on olive seedlings *Olea europaea* L. Irrigated with salt water

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Abstract

The research was conducted in the canopy of the Department of Horticulture and Landscape design- College of Agriculture - Al-Qasim Green University. Eighty-one olive seedlings were brought from government nursery in Babylon previnous. The seedlings of olive variety (Arbequina) were equally in size, and two factors were used. The two factors were potassium silicate (K_2siO_3) and Calcium oxide (CaO) with three concentrations (0, 2, 4 $ml.L^{-1}$).The research was designed as a factorial experiment according to a randomized complete block design (RCBD) with three replications. The results showed that the concentration of K_2siO_3 exceeded 4 $ml.L^{-1}$ and gave the highest values in all the studied characteristics (seedling height, seedling diameter, and number of leaves, number of branches, and chlorophyll content, carbohydrate content of the leaves) gave (77.12 cm, 13.24 mm, 216.78 leaves, 12.23 branches, 53.71 spad, and 5.75 $mg.g^{-1}$ dry weight) respectively. The concentration of 4 $ml.L^{-1}$ of CaO was superior in all characteristics that study and mentioned with K_2siO_3 and gave (77.53 cm, 14.21 mm, 266.87 leaves, 12.64 branches, 55.41 spad, and 5.48 mg.g-1 dry weight), respectively. The results of the statistical analysis were showed that the presence of significant interactions consisting of 4 $ml.L^{-1}$ of K_2siO_3 and CaO were superior gave the highest rate for all of the studied traits, while the interaction consisting of 0 $ml.L^{-1}$ of K_2siO_3 and CaO recorded the lowest rate for all of the studied traits.

Keywords: Calcium oxide, potassium silicate, Olive, *Olea europaea*, salt water.

Introduction

The olive, *Olea europaea* L. belongs to the Oleaceae family. It is one of the trees that has been cultivated since ancient times. The trees can live for more than a one thousand years, and its cultivation is widespread in the warm temperate regions of the world. Olive trees are evergreen. The leaves contain a thick layer of cutin. Its upper surface is green in color and the surface The bottom is silvery in color and contains down. These morphological features give it resistance to thirst and loss of water through transpiration and evaporation. The Mediterranean region is considered the original home of the olive, from where it spread to the rest of the world. The olive fruit has high nutritional value, due to its high oil content and small percentage of protein. Some of its types of wood are of great economic importance. Olive oil is one of the best vegetable oils. Olive oil has many benefits, as it improves the digestion process and facilitates bowel movement. The consistency and texture of olive oil helps stimulate the digestive system, making food move smoothly through the colon and thus reducing constipation. Consuming olive oil in the diet may enhance metabolism and aid bone growth. Maintaining hair health is one of the most important benefits of olive oil, as it is rich in vitamin E, which reduces hair loss [1].

Foliar feeding is the process of spraying nutrient solutions on the foliage at a concentration that ensures the maximum benefit for the plant while not causing harm to the plant. It requires precision in determining the appropriate concentration, especially for some elements between the limits of sufficiency and nutrient toxicity of the element. Research has indicated the role of foliar nutrition in ensuring the entry of the nutrient into the plant and then into tissue metabolism, which reduces the energy consumption required for the transport of element ions in the plant, in addition to saving a lot of effort and time due to its ability to mix fertilizers with pesticides and growth regulators. Foliar nutrition, especially with macroelements, is beneficial. During the advanced stages of plant growth, it plays an important role in reducing the need for adding it through the soil and thus providing nutrients while reducing effort and saving energy [2].

Potassium silicate K_2siO_3 is a very important compound for plants, as this compound works to provide the plant with two important elements, potassium and silicon, which has a positive effect on increasing vegetative growth, as well as increasing the trees' resistance to weather conditions and salt stress in the soil and water, increasing the trees' resistance to diseases, and increasing the tree's ability to store carbohydrates, thus increasing sugars in fruits [3]. Silicon is an essential element for plants as it increases plant growth. It also works to increase the degree of root spread in soil when added to the ground, and it also contributes to the activity of some other elements [4]. Silicon is one of the most abundant elements in the soil, but adding it to plants works to resist non-living stresses as well as stimulating antioxidant systems, which may lead to increased plant activity, especially in areas with high temperature [5].

Potassium is one of the important and mobile mineral elements that plants need, as its presence is considered necessary for the formation of carbohydrates and proteins, cell division, and tissue growth. It also has an impact on vital processes such as photosynthesis, respiration, transport, and ATP formation. It also contributes to phosphorylation processes, and potassium affects the activity of some other elements. It also opens and closes the stomata. It also helps the roots penetrate into the soil, and a lack of potassium leads to the cessation of growth and thus a decrease in yield [6].

In study by [7] on date palms, found that the Halawi variety, that there were significant differences in some vegetative and chemical traits when cuttings were treated with potassium fertilizer sprayed on the leaves. [8] studied the effect of spraying potassium silicate on seedlings of date palm cultivar Halawi and found that there were significant differences in some vegetative and chemical characteristics of the seedlings. Aisueni obtains differences in some vegetative and chemical characteristics when fertilizing palm cuttings with potassium.

The problem of salinity is one of the chronic problems that the Iraqi farmer suffers from. It affects production quantitatively and qualitatively through its effect on the chemical and physical properties of the soil, which negatively affects vegetative growth. Therefore, agricultural companies began searching for quick solutions to address this problem. CaO fertilizer is considered one of the solutions created by agricultural companies, which largely puts an end to this problem, as it works to increase plant activity in a distinctive way [9].

CaO fertilizer is a chlorine-free fertilizer added to agricultural lands to address salinity problems. What distinguishes this product, in addition to its efficiency, is the price of the product and its availability in the markets, as the farmer can wash a dunum of land with a package of this product whose price does not exceed 4,000 Iraqi dinars per kilogram, and thus the land is ready for cultivation within a period of 10 days.

CaO fertilizer is characterized by being a treatment for soil salinity problems in sprinkler irrigation systems or drip networks in which there are no septic tanks for washing and draining salty water. It also works to improve the properties of the soil by providing free calcium to the plant, as well as preventing their negative effects by raising the osmotic pressure of the plant roots. Preventing the penetration of the two elements into the roots, as these two elements prevent the plant from performing vital functions and reduce the ability of plants to absorb important elements and nutrients from the soil [10].

Because of the CaO content it contains, it plays an essential role in reducing the effect of salinity and increasing the readiness of nutrients, as it works to break the bond of the sodium element in the soil, replace the sodium element with calcium, and release the chlorine element, which has a toxic effect on the plant, and works to wash the sodium element into the lower layers of the soil [11].

In order to avoid the bad effects of abiotic stress, some researchers, including [12], recommended using CaO, which contains calcium, which is one of the main macronutrients important for plants, as it works to control a group of physiological processes to modify salt stress. Study by [13], [14], [15], calcium binds the sodium element that enters plant cells, and this in turn contributes to reducing the negative effects of salinity as found by [16]. The efficiency of foliar spraying as a fertilizer dose is important for the calcium element as a Ca++ source.

Calcium contributes to regulating plant growth and development and enhancing tolerance to abiotic stress Calcium is considered a secondary messenger that plays an important role as an important molecule in the mechanisms of recognizing abiotic stresses in plants and responding quickly to them under abiotic stresses. It either accumulates Calcium is inside plant cells or released outside them, carrying with it toxic negative ions [17].

[18] demonstrated the effect of calcium carbonate on the germination of *Lathyrus sataivus* L. After using concentrations (0, 2.5, 5, 10, 20, and 30%), significant differences were obtained in some vegetative and chemical traits. Pointed out by [19] indicated that Ca+2 sources had positive effects on root growth and the concentration of minerals in the leaves in his experiment on the Carica papaya plant. Laila et al. (2020) indicated that spraying olive trees with calcium at a rate of 0.5% using calcium chloride (CaCl) and chelated calcium led to Improving vegetative growth and the mineral contents of leaves

Aims of the research: The research aims to study the effect of K_2siO_3 and CaO and their interaction on some vegetative and chemical characteristics of olive seedlings irrigated with salty water.

Materials and methods

The study was conducted in the wood canopy of the Department of Horticulture and Landscape Engineering - College of Agriculture - Al-Qasim Green University, where one-year-old young olive seedlings were used. The size seedlings were equal in size and age of the olive variety (Arabicana), which were brought from the Horticulture and Forestry Station in Al-Husseiniyah / Karbala. The seedlings at the station were chosen, that were identical in height and age. After that, the seedlings were marked with indicative signs, and 81 seedlings were brought, which were divided into three groups, with 27 seedlings representing a replicate, and 3 seedlings for each replicate. The planting soil was prepared from river sand and the soil was sterilized by exposing to direct sunlight for two weeks before planting. Then the soil was sterilized with boiling water twice and left to dry. The used soil in the experiment was examined to determine some physical and chemical properties, Table (1).

Table 1: Some physical and chemical properties of the used soil before starting the experiment. Preparing experimental factors

the value	measruing unit	Property	
812	$g.\ kg^{-1}$	Sand	Soil separators
107		Silt	
84		Clay	
Sandy mixture	---	Soil texture	
7.38	---	pH	
1.6	$DS.\ M^{-1}$	EC	
0.03	%	N	Elements
0.08		P	
0.07		K	

Potassium silicate (K_2siO_3): The required concentrations of potassium silicate were prepared by dissolving each concentration separately in 100 mL of distilled water with continuous shaking in order for the solution to become homogeneous. Then the volume was increased to 1L of distilled water, and then the potassium silicate was sprayed 4 times each was 15 days after one spray. The seedlings were sprayed by sprayer with each volume until complete wetness.

Calcium oxide (CaO): The required concentrations were prepared by weighing each individual concentration of the substance CaO, dissolving in 100 mL of water, then completing the volume to 1L and adding it to the irrigation water for four times, each spray was after 15 days.

Irrigation water: In order to measure the extent of the effect of irrigation water salinity on the vegetative and chemical characteristics of olive seedlings, variety (Arabicana), the seedlings were watered with high-salinity water, the characteristics of which were according to the following table2.

Table 2: Some physical and chemical properties of the Irrigation water

The measured characteristic	measruing unit	Measurement result
EC	$DS\ .\ M^{-1}$	3.5
PH		7.8
Cl	mg.L	375
Na	mg.L	247

Experimental design: The experiment was designed as a factorial experiment according to a randomized complete block design (RCBD) with three replications. The experiment included two factors: the first factor was potassium silicate K_2siO_3, with three concentrations (0, 2, 4 ml.L^{-1}), and the second factor was calcium oxide, CaO with three concentrations: (0, 2, 4 ml.L^{-1}) [21].

Statistical analysis: The results were analyzed, and the factors were tested with their interactions using Genstat statistical program, and the differences between the means were compared according to the least significant difference (L.S.D) test at the 0.05 probability level

Result

Plant height rate

Table 3 The effect of spraying K_2siO_3 and ground addition CaO and Interaction on the seedling height rate of olive. cm.

K_2siO_3 rate	4	2	0	CaO / K_2siO_3
68.50	70.25	68.75	66.50	0
75.30	80.11	75.44	71.22	2
77.12	82.25	77.11	72.00	4
	77.53	73.76	69.90	rate CaO
	Interaction 1.8	CaO 0.9	K_2siO_3 0.9	L.S.D 0.05

The results in Table 3 showed that there are significant differences between the concentrations of K_2siO_3 where 4 ml.L^{-1} concentration was significantly superior to the other concentrations (0 and 2 ml.L^{-1}) gave the highest plant height of 77.12 cm. While the comparison treatment (0 ml.L^{-1}) gave the lowest average of plant height with 68.50 cm.

It is clear from the results of the table3 that there are significant differences between CaO concentrations, as the concentration of 4 ml.L^{-1} was significantly superior to the other concentrations and gave the highest plant height of 77.53 cm. While the comparison treatment with (0 ml.L^{-1}) gave the lowest average of plant height 69.90 cm.

The interactions of the table3 also showed significant differences between the experimental factors, as the interaction consisting of 4 ml.L^{-1} of K_2siO_3 and CaO was superior and gave the highest rate of plant height, reaching 82.25 cm. While the interaction treatment consisting of 0 ml.L^{-1} of K_2siO_3 and CaO was recorded as the minimum average of plant height was 66.50 cm.

Average main stem diameter

Table 4: The effect of spraying K_2siO_3 and ground addition CaO and Interaction on the average diameter of the main stem of olive seedlings mm.

rate K_2siO_3	4	2	0	CaO / K_2siO_3
12.63	13.99	12.75	11.17	0
13.01	14.11	13.44	11.50	2
13.24	14.55	13.19	12.00	4
	14.21	13.12	11.55	rate CaO
	Interaction 0.04	CaO 0.02	K_2siO_3 0.02	L.S.D 0.05

The results in Table 4 showed that there are significant differences between the concentrations of K_2siO_3 where 4 $ml.L^{-1}$ concentration was significantly superior to the other concentrations (0 and 2 $ml.L^{-1}$) gave the stem diameter 13.24 mm. While the comparison treatment (0 $ml.L^{-1}$) gave the lowest average of stem diameter with 12.63 mm.

It is clear from the results of the table4 that there are significant differences between CaO concentrations, as the concentration of 4 $ml.L^{-1}$ was significantly superior to the other concentrations and gave the stem diameter of 14.21 mm. While the comparison treatment with (0 $ml.L^{-1}$) gave the lowest average of stem diameter 11.55 mm.

The interactions of the table4 also showed significant differences between the experimental factors, as the interaction consisting of 4 $ml.L^{-1}$ of K_2siO_3 and CaO was superior and gave the highest rate of stem diameter, reaching 14.55 mm. While the interaction treatment consisting of 0 $ml.L^{-1}$ of K_2siO_3 and CaO was recorded as the minimum average of stem diameter was 11.17 mm.

Average number of leaves

Table 5 The effect of spraying K_2siO_3 and ground addition CaO and Interaction on the average number of leaves of olive seedlings leaf. $Plant^{-1}$

rate K_2siO_3	4	2	0	CaO / K_2siO_3
180.26	250.25	210.00	80.55	0
193.66	260.11	230.44	90.44	2
216.78	290.25	250.11	110.00	4
	266.87	230.18	93.66	rate CaO
	interaction 4.33	CaO 2.22	K_2siO_3 2.11	L.S.D 0.05

The results in Table 5 showed that there are significant differences between the concentrations of K_2siO_3 where 4 $ml.L^{-1}$ concentration was significantly superior to the other concentrations (0 and 2 $ml.L^{-1}$) gave the number of leaves 216.78 leaves. Plant While the comparison treatment (0 $ml.L^{-1}$) gave the lowest average of leaves. Plant with 180.26 leaves. Plant.

It is clear from the results of the table 5 that there are significant differences between CaO concentrations, as the concentration of 4 $ml.L^{-1}$ was significantly superior to the other concentrations and gave the number of leaves 266.87 leaves. Plant. While the comparison treatment with (0 $ml.L^{-1}$) gave the lowest average of number of leaves 93.66 leaves. Plant.

The interactions of the table 5 also showed significant differences between the experimental factors, as the interaction consisting of 4 ml.L^{-1} of K_2siO_3 and CaO was superior and gave the highest rate of number of leaves, reaching 290.25 leaves. Plant. While the interaction treatment consisting of 0 ml.L^{-1} of K_2siO_3 and CaO was recorded as the minimum average of number of leaves was 80.55 leaves. Plant.

Average number of branches

Table 6: The effect of spraying K_2siO_3 and ground addition CaO and Interaction on the average number of branches of olive seedlings branch. Plant.

rate K_2siO_3	4	2	0	CaO / K_2siO_3
9.80	11.25	10.10	8.12	0
10.56	12.14	11.11	8.44	2
12.23	14.55	13.16	9.00	4
	12.64	11.45	8.55	rate CaO
	interaction 0.05	CaO 0.03	K_2siO_3 0.02	L.S.D 0.05

The results in Table 6 showed that there are significant differences between the concentrations of K_2siO_3 where 4 ml.L^{-1} concentration was significantly superior to the other concentrations (0 and 2 ml.L^{-1}) gave the number of branches 9.80 branches. Plant. While the comparison treatment (0 ml.L^{-1}) gave the lowest average of leaves. Plant with 12.23 branches. Plant.

It is clear from the results of the table 6 that there are significant differences between CaO concentrations, as the concentration of 4 ml.L^{-1} was significantly superior to the other concentrations and gave the number of branches of 12.64 branches. Plant. While the comparison treatment with (0 ml.L^{-1}) gave the lowest average of number of leaves 8.55 branches. Plant.

The interactions of the table 6 also showed significant differences between the experimental factors, as the interaction consisting of 4 ml.L-1 of K_2siO_3 and CaO was superior and gave the highest rate of number of branches, reaching 14.55 branches. Plant. While the interaction treatment consisting of 0 ml.L^{-1} of K_2siO_3 and CaO was recorded as the minimum average of number of branches was 8.12 branches. Plant.

Chlorophyll content of leaves

Table 7: The effect of spraying K_2siO_3 and ground addition CaO and Interaction on the rate of chlorophyll in the leaves of olive seedlings SPAD.

rate K_2siO_3	4	2	0	CaO / K_2siO_3
50.17	53.25	51.15	46.12	0
52.20	55.14	51.99	49.47	2
53.71	57.85	52.55	50.74	4
	55.41	51.89	48.77	rate CaO
	interaction 0.05	CaO 0.03	K_2siO_3 0.02	L.S.D 0.05

The results in Table 7 showed that there are significant differences between the concentrations of K_2siO_3 where 4 $ml.L^{-1}$ concentration was significantly superior to the other concentrations (0 and 2 $ml.L^{-1}$) gave chlorophyll in the leaves 53.71 SPAD. While the comparison treatment (0 $ml.L^{-1}$) gave the lowest average of chlorophyll in the leaves 50.17 SPAD.

It is clear from the results of the table 7 that there are significant differences between CaO concentrations, as the concentration of 4 $ml.L^{-1}$ was significantly superior to the other concentrations and gave the chlorophyll in the leaves of 55.41 SPAD. While the comparison treatment with (0 $ml.L^{-1}$) gave the lowest average of chlorophyll in the leaves 48.77 SPAD.

The interactions of the table 7 also showed significant differences between the experimental factors, as the interaction consisting of 4 $ml.L^{-1}$ of K_2siO_3 and CaO was superior and gave the highest rate of chlorophyll in the leaves 57.85 SPAD. While the interaction treatment consisting of 0 $ml.L^{-1}$ of K_2siO_3 and CaO was recorded as the minimum average of chlorophyll in the leaves was 46.12 SPAD.

Carbohydrate content of leaves

Table 8: The effect of spraying K_2siO_3 and ground addition CaO and Interaction on the rate of Carbohydrate content of leaves of olive seedlings $mg.g^{-1}$ dry weight .

rate K_2siO_3	4	2	0	CaO / K_2siO_3
4.94	5.35	5.25	4.22	0
5.23	5.24	5.99	4.47	2
5.75	5.85	5.66	5.74	4
	5.48	5.63	4.81	rate CaO
	interaction 0.008	CaO 0.004	K_2siO_3 0.004	L.S.D 0.05

The results in Table 8 showed that there are significant differences between the concentrations of K_2siO_3 where 4 $ml.L^{-1}$ concentration was significantly superior to the other concentrations (0 and 2 $ml.L^{-1}$) gave Carbohydrate content of leaves 5.75 $mg.g^{-1}$ dry weight. While the comparison treatment (0 $ml.L^{-1}$) gave the lowest average of Carbohydrate content of leaves 4.94 $mg.g^{-1}$ dry weight.

It is clear from the results of the table 8 that there are significant differences between CaO concentrations, as the concentration of 4 ml.L^{-1} was significantly superior to the other concentrations and gave the Carbohydrate content of leaves of 5.48 mg.g^{-1} dry weight. While the comparison treatment with (0 ml.L^{-1}) gave the lowest average of Carbohydrate content of leaves 4.81 mg.g^{-1} dry weight.

The interactions of the table 6 also showed significant differences between the experimental factors, as the interaction consisting of 4 ml.L^{-1} of K_2siO_3 and CaO was superior and gave the highest rate of Carbohydrate content of leaves 5.85 mg.g^{-1} dry weight. While the interaction treatment consisting of 0 ml.L^{-1} of K_2siO_3 and CaO was recorded as the minimum average of Carbohydrate content of leaves was 4.22 mg.g^{-1} dry weight.

Discution

The effect of spraying different concentrations of K_2siO_3 on the studied characteristics. It is clear from the results of tables (3, 4, 5, 6, 7,and 8)mentioned that spraying with potassium silicate led to increase in vegetative growth characteristics and chemical contents of chlorophyll and carbohydrates from leaves . This increase may be due to the role of K_2siO_3, as silicon is considered an essential element for the plant. Moreover, it increases plant growth at the height rates of deferent growth stage. It also works to increase the degree of root spread upon ground application. Furthermore, it contributes to the activity of some other elements, which reflects positively on vegetative growth [4]. The reason may be that the silicon element works to resist inanimate stresses. In addition, to stimulating antioxidant systems, which may lead to increased plant activity, especially in areas with high temperatures, especially in Iraq, which is classified as a hot region [5].

Potassium is considered one of the important and mobile mineral elements that the plant needs, as it is considered as necessary for the formation of carbohydrates and proteins, cell division, and tissue growth. It also has an impact on vital processes such as photosynthesis, respiration, transport, and ATP formation. It is contributed to phosphorylation processes, and potassium affects the activity of potassium and other elements, all of these things have caused an increase in vegetative growth, which has led to an increase in the chlorophyll contents of the leaves in well as the opening and closing of stomata, which helps the entry of these elements into the plant. It helps the roots to penetrate into the soil, and a lack of potassium leads to reduce of yield and stunted growth [6]. These results are consistent with what was mentioned by [8] , [7], [16].

The effect of ground addition with CaO on the traits under study. From the results of tables (3, 4, 5, 6, 7 , and 8), ground addition with CaO led to a significant increase in the studied vegetative growth characteristics. The reason is due to the role of CaO fertilizer, as it is considered a suitable treatment for soil salinity problems. The reason also may be due to the role of CaO in improving the properties of Physical and chemical soil, by providing free calcium to the plant, and the ability to neutralize and clean the soil from the elements sodium and chlorine, which cause toxicity to plants, as well as preventing their negative impact by raising the osmotic pressure on the roots. The plants were preventing the penetration of the two elements into the root, which hinders the plant from performing its vital functions and reduces the ability of plants to absorb important elements and nutrients from the soil. The CaO has the ability to prevents the formation of toxic ions in the soil and works to increase plant activity in a distinctive way by breaking the bond of the sodium element to the soil and also replacing it with calcium, which causes the sodium element to be washed out and descend to the lower layers of the soil. In addition, it may be to releasing the chlorine element, which becomes free and thus can be easily washed and neutralized. All of these led to an increase in the plant's absorption of nutrients, thus increasing vegetative growth, as well as being reflected in an increase in the content of chlorophyll and carbohydrates.

The reason for the increase in the vegetative and chemical characteristics of olive seedlings may be due to the fact that calcium contributes to regulating plant growth and development and enhancing tolerance to abiotic stress, as calcium is considered a secondary messenger that plays an important role as an important molecule in the mechanisms of recognizing abiotic stresses in plants and responding quickly to them. Either calcium accumulates inside plant cells or released outside them, carrying with it toxic negative ions. This is reflected positively in increased vegetative growth, which is turn as a reason for increasing chlorophyll and carbohydrates contents [17], [22]. These results are consistent with the findings of a group of researchers [18], [20].

Conclusion

In conclusion, the research concludes that the concentration of4 $ml.L^{-1}$ of K_2siO and 4 $ml.L^{-1}$ of CaO excelled morally in all the studied characteristics. Therefore, the findings recommend that using higher concentrations of experiment trails with the same plant or with other plant in same family can improved all characteristics. Furthermore, using different fruit seedlings of the studying variety and higher concentrations of nutrients that used in the experiment will be good for further studies.

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