



Impact of Olive Trees cv. *Sorani* to Foliar Application with Potassium and Zinc Fertilizer

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ABSTRACT

The effects of foliar potassium and zinc sprays on vegetative growth, yield, and fruit quality of *Olea europaea* L. cv. "Sorani" were evaluated in a field experiment conducted in Bakrajo, Sulaimaniyah, Kurdistan–Iraq, during the 2024 growing season. Fifteen-year-old olive trees planted at 4 × 4 m spacing were arranged in a factorial randomized complete block design with three replications. Twenty-seven uniform trees were assigned to nine combinations of potassium (0, 1.5, and 3 ml.l⁻¹) and zinc (0, 1.5, and 3 g.l⁻¹) liquid form of foliar sprays, applied three times beginning on 3 July 2024. The findings showed that although zinc mainly increased leaf zinc level, potassium application considerably improved vegetative features, such as leaf area, leaf dry weight, and leaf potassium concentration. Potassium at 3 ml.l⁻¹ and zinc at 1.5 g.l⁻¹ produced the greatest values for yield components, such as fruit fresh and dry weight, fruit length, and fruit diameter, which showed significant positive responses to both nutrients. The combined application of 3 ml.l⁻¹ potassium and 1.5 g.l⁻¹ zinc produced the highest yield (9.57 kg tree⁻¹), and total yield per tree rose significantly under these treatments. While potassium boosted fruit potassium content, oil percentage and zinc concentration rose dramatically with foliar zinc, improving fruit quality features. Potassium did not cause a significant response in total soluble solids, whereas zinc did. The lack of both nutrients resulted in the lowest results across all parameters, suggesting a significant detrimental impact of nutritional insufficiency. Overall, the study finds that foliar treatment of zinc and potassium, especially at 1.5 g.l⁻¹ and 3 ml.l⁻¹, respectively, significantly improves fruit quality, growth, and productivity of "Sorani" olive trees in the semi-arid environment of Kurdistan.

Keywords: Olive, Potassium, Zinc, Foliar application, yield

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INTRODUCTION

One of the earliest fruit species to be grown, the olive tree (*Olea europaea* L.) has substantial cultural, nutritional, and commercial importance. Its enduring significance to human communities, who have relied on its fruits and oil for sustenance and therapeutic reasons since ancient times, is reflected in religious scriptures that refer to it as a fortunate tree. Rich in carbs, vitamins, minerals, and premium oil, olive fruits significantly meet human nutritional demands and provide a number of health advantages[1]. The olive tree, a perennial with remarkable lifespan that sometimes lasts for centuries, has been essential to the economics of Mediterranean nations like Palestine, Syria, and Lebanon. Olive agriculture has spread around the world from its birthplace in the Mediterranean Basin, with an estimated 750 million trees presently farmed in a variety of climates[2].

Olives' dual use as table olives and oil, both of which are significant components of the human diet, reflects their nutritional worth[3]. Along with vital minerals like K, Ca, Mg, Cu, Se, and P, olive fruits also include crucial vitamins like A, B, C, D, and E. About 50–70 g of moisture, 18–35 g of fat, 18 g of carbohydrates, and 1–3 g of protein are included in 100 grams of the edible part [4]. Antioxidants, monounsaturated fatty acids, and bioactive substances including oleuropein, hydroxytyrosol, tyrosol, and other carotenoids are abundant in olive oil, especially extra virgin olive oil. These substances further demonstrate the oil's beneficial effects on health by preventing type 2 diabetes, cancer, and cardiovascular illnesses [5]. Olive production is linked to a number of environmental problems, such as resource depletion, soil degradation, and waste production, despite the crop's nutritional and economic advantages. However, olive trees are well suited to challenging environmental circumstances like drought and extreme heat [6].

The olive has historically flourished in the Mediterranean climate, which is marked by irregular rainfall that ranges from 150 to 800 mm per year, with precipitation concentrated in the winter and spring [7]. More than 3,000 olive groves contribute considerably to local production in Iraq's Kurdistan Region alone, particularly in the Bashiqa region of Ninawa Province, where olives are used for pickling and oil extraction because of their high nutritional and economic value[8]. When nutrient levels are somewhat sufficient but not inadequate, olive trees are known to generate good harvests even under low-vigor situations [9].

However, environmental challenges like salt and drought significantly limit root absorption and nutrient mobility in the soil, resulting in nutritional imbalances that impair tree performance[10]. As a result, foliar fertilization has emerged as a critical technique for delivering vital nutrients straight to the canopy, guaranteeing quick absorption and reducing shortages that frequently arise under unfavorable soil conditions[11]. This technique works especially well in dry and semi-arid areas where foliar treatments of elements like zinc, boron, and potassium have been demonstrated to boost physiological performance and fruit quality [12]. Foliar fertilization is an effective substitute for soil fertilization in water-limited conditions because nutrients applied to leaves are absorbed quickly (e.g., 0.5–2 hours for N and 10–24 hours for K) [13].

One of the most important agricultural techniques influencing olive tree output and fruit quality, particularly with regard to potassium and vitamin availability, is fertilization [14]. Potassium (K) is crucial for olive growth because it maintains water balance, initiates various enzymatic activities, and enables nutrient transport within the plant, thereby directly impacting fruit development and oil production[15]. Zinc (Zn), an essential micronutrient, plays an important role in physiological and biochemical processes such as enzyme activation, chlorophyll generation, reproductive development, and auxin synthesis, which govern cell elongation, shoot growth, and canopy expansion [16]. Olive varieties are spread in different locations based on soil type and rainfall patterns. In Syria, cultivars are selected and classified according to specified morphological and agronomic criteria [17]. The Sorani (Maari) cultivar, commonly planted in Aleppo, Harem, and Jisr al-Shughour, is notable for its high oil content (25–32%) and resilience to semi-arid settings [18].

Given the economic, nutritional, and therapeutic importance of olive production in Iraq, enhancing tree performance and sustaining long-term yield remain top agricultural goals. Olive orchards in the region confront a number of management issues, including fertilizer constraints, irregular yields, and environmental pressures. The current study seeks to increase vegetative development, fruit output, and fruit quality of the Sorani olive cultivar by applying varied quantities of potassium and zinc as foliar sprays at three intervals. The project aims to increase oil content, optimize nutritional balance, and encourage long-term production in Kurdistan's semi-arid climate.

Material and Methods

Experimental Design and Statistical Analysis:

The study was carried out during season 2024 at orchard that located in Bakrajo in Sulaimany city, in Directorate of Olive Horticulture and Nurseries in Bakrajo, General Directorate of Agriculture in Sulaimanyia, Affiliated to the Ministry of Agriculture and Water Resources, which is located in North-East of Iraq (latitude: 35.55033 N, longitude: 45.35262 E), and an Altitude of (746 m) above sea level. The study area's climate is often defined by cold winters and hot, dry summers [19].

The experiment included two factors:

Potassium and zinc foliar sprays were applied at three concentrations each (0, 1.5, and 3 ml.l⁻¹ for potassium; 0, 1.5, and 3 g.l⁻¹ for zinc) in an experiment consisting of 27 treatment combinations (3 × 3 × 3), each with three replications. Each replication was represented by a tree, with a total of 27 trees used in the study. The experiment was arranged in a factorial Randomized Complete Block Design (RCBD). The mean values will be compared using Duncan's multiple range test (DMRT) at a 0.05 probability level [20]. The data were analyzed using SAS [21].

Treatments:

This study was conducted to examine the effects of topically applying the brand Sorani. The brand contains potassium, which was prepared at concentrations of (0, 1.5, and 3 ml.l⁻¹), and Zinc, prepared at concentrations of (0, 1.5, and 3 g.l⁻¹). The study evaluated the development, productivity, and fruit quality of 15-year-old olive trees. During the growing season, each tree was sprayed three times. On March 7 / 2024, at 6 AM, K was first sprayed onto the leaves. The second K application occurred on March 22 / 2024. There was a 15-day interval between the second and third sprays. The first zinc foliar spray was applied on March 8 / 2024, at 6 AM, followed by the second Zn spray on March 23 / 2024. The interval between the second and third Zn sprays was also 15 days.

Studied characteristics:

Leaf Area (cm²)

It was determined by collecting 30 olive leaves in each sample randomly and weighing them using the portable

leaf area meter AM350 [22].

Leaf dry weight (g)

In each selected shoot, 50 leaves were collected and weighed, then dried at 70°C for 72 hours and weighed again using an electronic balance [23].

Leaf content of Potassium %

Using a flame photometer, the percentage of potassium was calculated [24].

Leaf content of Zinc %

The Atomic Absorption Spectrophotometer was used to determine the microelements of zinc [25].

Average fruit weight (g)

Five olive fruits were chosen at random from each sample, weighed using an electronic scale set to (0.0001 g) accuracy, and the average weight was then determined [26].

Fruit Dry Weight (g)

Ten randomly selected olive fruits were dried in an oven at 70°C until their weight remained unchanged, and the total dry weight was then divided by ten to determine the average dry weight of a fruit .

Average fruit length (mm)

Six randomly selected fruits from each sample were measured for length using a Vernier caliper, averaged, and expressed in millimeters (mm) with a (0.01 mm) precision .

Average fruit diameter (mm)

The diameter of six randomly selected fruits from each sample in each replicate was measured using a Vernier caliper, averaged, and expressed in millimeters (mm) with (0.01 mm) accuracy.

Total yield (Kg. tree⁻¹)

Harvesting all the fruits from each selected tree at full maturity and weighing the entire fruit mass with a field scale allowed for calculating the total yield per tree .

Fruit oil percentage % [27]

Total soluble solids (TSS %) [28]

Fruit content of potassium % [29]

Fruit content of zinc % [30]

Results

Impact of Foliar Spray of Potassium and Zinc on vegetative growth:

Leaf Area (cm²)

Foliar potassium treatment had a considerable influence on leaf area, as seen in Table 1. The injection of 1.5 ml.l⁻¹ K resulted in the largest leaf area (3.82 cm²), substantially higher than the control (3.20 cm²). The 3 ml.l⁻¹ K treatment resulted in an intermediate value (3.40 cm²), which was not substantially different from the control or 1.5 ml.l⁻¹. This suggests a partly positive but non-significant response at higher potassium levels. However, foliar zinc treatment had no significant influence on leaf area. Zinc levels (0, 1.5, and 3 g.l⁻¹) resulted in identical leaf areas (3.37, 3.69, and 3.36 cm²), suggesting no substantial effect on this feature. Regarding the potassium-zinc interaction, the combined treatments caused various but non-significant effects. Some combinations, such as 1.5 ml K × 1.5 g Zn (3.70 cm²) and 1.5 ml K × 0 Zn (3.91 cm²), recorded relatively higher values, but were not substantially different from the majority of combinations. This suggests that the interaction had no substantial synergistic or antagonistic effects on leaf area. Overall, potassium at 1.5 ml.l⁻¹ considerably increased leaf area, but zinc and the K × Zn combination showed no significant effects.

Leaf dry weight (g)

Potassium administration substantially enhanced leaf dry weight, with 1.5 and 3 ml.l⁻¹ giving higher values (9.52 and 9.90 g) than the control (8.96 g). Zinc treatment had no meaningful impact, since all zinc levels produced equal dry weights. Although certain combinations resulted in numerically larger values, the K × Zn interaction did not indicate significant changes. Overall, potassium exhibited a favorable and substantial effect on leaf dry weight, while zinc and the interaction had no significant impact.

Table (1): Effect of Potassium and Zinc application and their interactions on Vegetative characteristic on Oliv "Sorani"

Treatments		Leaf area (Cm ²)	Leaf dry weight (g)	Leaf content of Potassium %	Leaf content of Zinc %
Potassium (ml .l ⁻¹)	0	3.20 b	8.96 b	0.734 b	0.276 b
	1.5	3.82 a	9.52 a	0.836 a	0.367 a
	3	3.40 ab	9.90 a	0.895 a	0.373 a
Zinc (g .l ⁻¹)	0	3.37 a	9.46 a	0.798 a	0.316 b
	1.5	3.69 a	9.53 a	0.837 a	0.328 ab
	3	3.36 a	9.40 a	0.830 a	0.372 a
0	0	2.91 b	8.45 d	0.627 c	0.201 c
	1.5	3.70 ab	9.07 cd	0.749 bc	0.263 bc
	3	2.99 ab	9.38 abc	0.827 ab	0.365 a
1.5	0	3.91 ab	9.89 ab	0.833 ab	0.394 a
	1.5	4.02 a	9.42 abc	0.832 ab	0.319 ab
	3	3.52 ab	9.25 bc	0.843 ab	0.388 a
3	0	3.29 ab	10.03 a	0.936 a	0.353 a
	1.5	3.33 ab	10.10 a	0.931 a	0.401 a
	3	3.57 ab	9.58 abc	0.820 ab	0.364 a

* Means within individual factors and their interactions followed by the same letters are not significantly different from each other according to Duncan's multiple range test ($P \leq 0.05$).

Potassium content of leaf (%)

The content of potassium in olive leaves was significantly improved by foliar potassium spray. While raising potassium levels to 1.5 ml.l⁻¹ and 3 ml.l⁻¹ produced noticeably higher values (0.836% and 0.895%, respectively), the control treatment had the lowest leaf K content (0.734%). This pattern shows that when potassium content rose, nutritional absorption clearly improved. On the other hand, there was no discernible impact of foliar zinc administration on the potassium content of leaves. Zinc did neither increase or decrease potassium accumulation in the leaves, as seen by the statistically similar observed values (0.798%, 0.837%, and 0.830% for 0, 1.5, and 3 g L⁻¹ Zn, respectively). Potassium and zinc (K × Zn) interacted to create varying but often non-significant changes. While certain combinations, such as 3 ml K × 1.5 g Zn, had comparatively greater K percentages, these values did not vary significantly from the other treatments. This implies that the administration of K and Zn together did not provide a synergistic impact on leaf potassium content that was greater than that of potassium alone. Overall, zinc and the K × Zn interaction had non-significant effects, whereas leaf potassium concentration responded considerably and favorably to potassium administration.

Zinc Content of leaf (%)

The content of zinc in leaves was significantly improved by foliar potassium treatment. Applying 1.5 ml.l⁻¹ and 3 ml.l⁻¹ K considerably raised leaf Zn levels to 0.367% and 0.373%, respectively, whereas the control treatment had the lowest Zn content (0.276%). This suggests that zinc absorption and accumulation in the leaf tissues were improved by potassium. On the other hand, foliar zinc treatment had a considerable impact; with 3 g.l⁻¹ Zn, leaf Zn content increased from 0.316% in the control to 0.372%. The intermediate level (1.5 g.l⁻¹) produced 0.328%, which was

lower than the highest Zn level but not substantially different from the control. These findings demonstrate that applying zinc, especially at 3 g.l^{-1} , successfully increased the content of zinc in leaves. Potassium and zinc ($\text{K} \times \text{Zn}$) interacted to produce considerable but not entirely meaningful changes. The highest Zn concentrations were attained by a number of combination treatments, particularly those with larger concentrations of both nutrients. For example, $1.5 \text{ ml K} \times 3 \text{ g Zn}$ and $3 \text{ ml K} \times 1.5\text{--}3 \text{ g Zn}$ recorded leaf Zn values over 0.37%. Even while the overall interaction

Table (2): Effect of Potassium and Zinc application and their interactions on Yield characteristic on Olive tree cv. "Sorani"

Treatments		Fruit fresh weight (g)	Fruit dry weight (g)	Fruit length (mm)	Fruit diameter (mm)	Tree yield (Kg)
Potassium (ml .l ⁻¹)	0	3.05 b	1.08 a	24.77 b	19.96 b	6.33 b
	1.5	2.97 b	1.03 a	24.14 b	19.92 b	6.04 b
	3	3.67 a	1.44 a	26.66 a	21.94 a	7.49 a
Zinc (g .l ⁻¹)	0	2.64 b	0.81 b	23.40 b	18.77 b	6.64 a
	1.5	3.86 a	1.59 a	26.25 a	21.94 a	7.56 a
	3	3.19 b	1.15 b	25.92 a	21.10 a	5.66 b
0	0	1.87 d	0.41 c	21.33 d	16.10 c	6.72 b
	1.5	3.95 ab	1.61 ab	25.99 abc	21.55 ab	6.50 b
	3	3.33 abc	1.23 abc	26.98 ab	22.22 ab	5.79 b
1.5	0	2.65 cd	0.77 bc	23.22 cd	19.66 b	6.16 b
	1.5	3.25 abc	1.25 abc	24.66 abcd	20.55 b	6.60 b
	3	3.01 bc	1.08 abc	24.55 bcd	19.55 b	5.35 b
3	0	3.41 abc	1.25 abc	25.66 abc	20.55 b	7.05 b
	1.5	4.39 a	1.91 a	28.10 a	23.73 a	9.57 a
	3	3.23 abc	1.15 abc	26.22 abc	21.55 ab	5.85 b

*Means within individual factors and their interactions followed by the same letters are not significantly different from each other according to Duncan's multiple range test ($P \leq 0.05$).

impact was favorable, it was not consistently significant across treatments, as several combinations continued to be statistically equivalent. Both potassium and zinc foliar treatment considerably and favorably affected the zinc content of the leaves overall, with potassium enhancing Zn absorption and the highest Zn level resulting in the largest Zn accumulation in the leaves.

Impact of Foliar Spray of Potassium and Zinc on yield parameters:

Fruit fresh weight (g)

Fruit fresh weight was significantly impacted by foliar potassium treatment. The greatest result was found at $3 \text{ ml.l}^{-1} \text{ K}$ (3.67 g), which was substantially bigger than both the control (3.05 g) and the 1.5 ml.l^{-1} treatment (2.97 g). Only at the maximum potassium level did this exhibit a favorable and substantial improvement in fruit fresh weight; the lower dose did not significantly vary from the control. Applying zinc also resulted in a noteworthy reaction. In comparison to the control (2.64 g) and the 3 g.l^{-1} level (3.19 g), the maximum fruit fresh weight (3.86 g) was measured at $1.5 \text{ g.l}^{-1} \text{ Zn}$. This indicates that while the highest Zn level did not much increase fresh weight, zinc at 1.5 g.l^{-1} had a large favorable impact. Positive and somewhat significant effects were seen when potassium and zinc ($\text{K} \times \text{Zn}$) interacted. Out of all the treatments, the combination of $3 \text{ ml K} \times 1.5 \text{ g Zn}$ yielded the greatest fruit fresh weight (4.39

g), demonstrating a strong synergistic effect. The interaction impact was positive but not consistently significant, as seen by the statistical similarity of several different combinations. Overall, both potassium and zinc had a substantial effect on fruit fresh weight; the greatest benefit was shown when 3 ml K $\times$ 1.5 g Zn were applied together.

Fruit dry weight (g)

Fruit dry weight was not significantly affected by foliar potassium treatment. The greatest numerical value (1.44 g) was found at 3 ml.l⁻¹ K, although it did not differ significantly from either the 1.5 ml.l⁻¹ treatment (1.03 g) or the control (1.08 g). This suggests that there was no statistically significant increase in fruit dry matter caused by potassium. Fruit dry weight, on the other hand, was significantly impacted by zinc foliar spray. The greatest value (1.59 g) was obtained by applying 1.5 g.l⁻¹ Zn, which was much higher than the control (0.81 g) and the 3 g L⁻¹ level (1.15 g). This shows that fruit dry weight was strongly improved by zinc at 1.5 g.l⁻¹, but it was not significantly improved by greater zinc concentrations. Partially significant changes resulted from the interaction between potassium and zinc (K $\times$ Zn). The combination of 3 ml K $\times$ 1.5 g Zn produced the greatest dry weight (1.91 g), suggesting a favorable synergistic impact. The interaction was not consistently significant across treatments, though, since a number of additional combinations continued to be statistically equivalent. Overall, zinc treatment had a considerable impact on fruit dry weight, especially at 1.5 g.l⁻¹, but potassium by itself had no discernible effect. In some combinations, particularly 3 K $\times$ 1.5 Zn, the K $\times$ Zn interaction increased dry weight.

Average fruit length (mm)

The average fruit length was significantly improved by foliar potassium spray. In comparison to the control (24.77 mm) and the 1.5 ml.l⁻¹ treatment (24.14 mm), the greatest result (26.66 mm) was recorded at 3 ml L⁻¹ K. This suggests that whereas the lower dose did not significantly improve fruit length, only the maximum potassium amount was able to do so. Zinc foliar treatment also had a significant effect. Adding 1.5 g.l⁻¹ and 3 g.l⁻¹ Zn led to considerably longer fruits (26.25 mm and 25.92 mm) compared to the control (23.40 mm). Zinc treatment, especially at 1.5 g/l, significantly improved fruit elongation. The interaction of potassium and zinc (K $\times$ Zn) yielded favorable and somewhat significant results. The combination of 3 ml K and 1.5 g Zn resulted in the longest fruits (28.10 mm), indicating a definite synergistic impact. Several combinations, such as 3 ml K $\times$ 0 Zn (25.66 mm) and 1.5 ml K $\times$ 3 g Zn (26.98 mm), exhibited better fruit length, but differences were not consistently significant across all pairings. Overall, fruit length responded considerably to potassium and zinc, with the highest gain recorded under the combination treatment (3 ml K $\times$ 1.5 g Zn).

Average fruit diameter (mm)

Foliar potassium and zinc treatment had a significant impact on the average fruit diameter of olive cv. Sorani. Potassium at 3 ml.l⁻¹ increased fruit diameter significantly compared to the control and 1.5 ml.l⁻¹ treatments, which exhibited no significant changes. Zinc treatment had a substantial favorable effect, as 1.5 and 3 g.l⁻¹ produced bigger fruit diameters than the zinc control. The combination of 3 ml.l⁻¹ potassium + 1.5 g.l⁻¹ zinc resulted in the largest fruit diameter, demonstrating a significant synergistic effect. However, the untreated combination (0 K $\times$ 0 Zn) generated the smallest fruit, indicating a detrimental impact of nutritional deficiencies.

Total yield (Kg.tree⁻¹)

The foliar spray of potassium and zinc greatly increased the overall fruit output of olive cv. Sorani. Potassium at 3 ml.l⁻¹ resulted in the greatest yield (7.49 kg tree⁻¹), indicating a substantial beneficial impact compared to the control and 1.5 ml.l⁻¹ treatments, which did not differ significantly and therefore demonstrated a non-significant effect at lower potassium levels. Zinc administration had a substantial impact on production, with 1.5 g.l⁻¹ generating the highest yield (7.56 kg tree⁻¹) and varying considerably from both the zinc control and the 3 g.l⁻¹ treatment. This suggests that 1.5 g.l⁻¹ is the best zinc level. The combination of 3 ml.l⁻¹ potassium and 1.5 g.l⁻¹ zinc had the best total yield (9.57 kg tree⁻¹), indicating a strong synergistic and beneficial interaction. In contrast, numerous interaction treatments without enough potassium or zinc yielded lower yields, with the lowest values seen in combinations missing balanced nutrient delivery, showing the deleterious impact of nutrient deficit on tree production. Overall, the findings indicate that potassium and zinc, particularly when administered at their optimum quantities, are critical for increasing olive tree productivity.

Impact of Foliar Spray of Potassium and Zinc on chemical parameters:**Fruit oil percentage (%)**

Foliar potassium and zinc treatment had a significant impact on the fruit oil % of olive variety Sorani. Potassium injection increased oil content significantly, from 24.13% in the control to 25.88% at 1.5 ml.l⁻¹ and 25.30% at 3 ml.l⁻¹. The higher potassium levels did not differ significantly from each other, showing a non-significant impact between 1.5 and 3 ml.l⁻¹. However, both demonstrated a considerable favorable effect compared to the control. Zinc

Table (3): Effect of Potassium and Zinc application and their interactions on Chemical characteristic on Olive "Sorani"

Treatments		Fruit oil percentage %	TSS %	Fruit content of potassium %	Fruit content of zinc %
Potassium (ml .l ⁻¹)	0	24.13 b	16.16 a	0.630 b	0.246 b
	1.5	25.88 a	16.33 a	0.677 a	0.368 a
	3	25.30 a	16.45 a	0.687 a	0.367 a
Zinc (g .l ⁻¹)	0	23.87 b	15.80 b	0.672 a	0.317 a
	1.5	25.85 a	16.30 ab	0.669 a	0.341 a
	3	25.59 a	16.84 a	0.654 a	0.322 a
0	0	21.76 c	15.11 b	0.580 d	0.206 d
	1.5	26.30 ab	16.26 ab	0.638 bcd	0.262 c
	3	24.32 b	17.10 a	0.673 abc	0.271 c
1.5	0	25.00 ab	15.93 ab	0.733 a	0.350 ab
	1.5	26.04 ab	16.50 ab	0.630 bcd	0.372 a
	3	26.60 a	16.56 ab	0.669 abc	0.381 a
3	0	24.85 ab	16.36 ab	0.704 ab	0.396 a
	1.5	25.21 ab	16.13 ab	0.740 a	0.389 a
	3	25.84 ab	16.86 ab	0.618 cd	0.316 b

*Means within individual factors and their interactions followed by the same letters are not significantly different from each other according to Duncan's multiple range test ($P \leq 0.05$).

application increased oil percentage from 23.87% to 25.85% at 1.5 g.l⁻¹ and 25.59% at 3 g.l⁻¹. However, the zinc control had the lowest oil value among the treatments. The combination of potassium and zinc indicated much more potent effects. The (0 K × 0 Zn) treatment had the lowest oil percentage (21.76%), indicating a detrimental impact when both elements were lacking. Several combinations resulted in high oil values, including 26.30% (0 K × 1.5 Zn), 26.60% (K 1.5 × Zn 3), and 25.84% (K 3 × Zn 3). The maximum oil percentage was reported at 26.60% under 1.5 ml.l⁻¹ potassium paired with 3 g.l⁻¹ zinc, indicating a considerable and significantly beneficial interaction effect. Overall, both nutrients increased fruit oil percentage, both singly and in combination, with combined treatments showing the greatest gain.

Total Soluble Solids (TSS %)

When potassium and zinc were applied topically, the olive cultivar Sorani's total soluble solids (TSS%) concentration responded differently. TSS values were statistically similar at all potassium doses, ranging from 16.16% in the control to 16.33% and 16.45% at 1.5 and 3 ml.l⁻¹, respectively, indicating that potassium had no significant influence. Zinc treatment, on the other hand, led to a notable rise in TSS, with values increasing from 15.80% in the

zinc control to 16.30% at 1.5 g.l^{-1} and reaching the maximum level of 16.84% at 3 g.l^{-1} . This suggests that zinc has a considerable beneficial impact on the accumulation of soluble solids. This pattern was further demonstrated by the interaction between potassium and zinc, where the nutrient-deficient combination ($0 \text{ ml.l}^{-1} \text{ K} \times 3 \text{ g.l}^{-1} \text{ Zn}$) produced the lowest TSS (15.11%), whereas $0 \text{ ml.l}^{-1} \text{ K} \times 3 \text{ g.l}^{-1} \text{ Zn}$ produced the greatest TSS (17.10%), confirming zinc's dominating role in raising TSS concentration. Overall, zinc treatment considerably enhanced TSS%, but potassium exerted no discernible influence on this characteristic.

Fruit potassium content %

Foliar potassium treatment had a considerable impact on the fruit potassium level of the olive variety Sorani, whereas zinc had no discernible primary effect. Potassium fertilization significantly improved fruit potassium concentration, which rose from 0.630% in the control to 0.677% and 0.687% at 1.5 and 3 ml.l^{-1} , respectively. Zinc treatments, on the other hand, resulted in non-significant variations, with values ranging narrowly between 0.654% and 0.672%, suggesting that zinc by itself had no effect on fruit potassium buildup. However, the interaction between zinc and potassium showed a number of noteworthy reactions. A favorable synergistic effect was demonstrated by the maximum potassium content (0.740%) under 3 ml.l^{-1} potassium $\times$ 1.5 g.l^{-1} zinc, whereas a negative impact of nutrient exclusion was indicated by the lowest value (0.580%) under the $0 \text{ ml.l}^{-1} \text{ K} \times 0 \text{ g.l}^{-1} \text{ Zn}$ treatment. Overall, the application of potassium greatly increased the content of potassium in fruit, whereas zinc had no impact on its own but, when coupled with potassium, contributed to numerous better results.

Fruit zinc content (%)

Foliar treatments of zinc and potassium had a substantial effect on the fruit zinc content of the olive cultivar Sorani. Zinc concentration increased from 0.246% in the control to 0.368% and 0.367% at 1.5 and 3 ml.l^{-1} potassium, respectively, as a result of potassium treatment. Fruit zinc content was also significantly increased by zinc treatment, increasing from 0.317% in the zinc control to 0.341% and 0.322% at 1.5 and 3 g.l^{-1} , with the greatest values occurring at intermediate zinc doses. The most noticeable changes were caused by the interaction between potassium and zinc. The $0 \text{ ml.l}^{-1} \text{ K} \times 0 \text{ Zn}$ treatment had the lowest zinc level (0.206%), suggesting a significant detrimental impact of nutritional deprivation. The greatest fruit zinc concentrations, on the other hand, such as 0.381% ($1.5 \text{ ml.l}^{-1} \text{ K} \times 3 \text{ g.l}^{-1} \text{ Zn}$) and 0.396% ($3 \text{ ml.l}^{-1} \text{ K} \times 0 \text{ g.l}^{-1} \text{ Zn}$), showed that both nutrients may considerably increase zinc accumulation when given either together or in complementary combinations. Overall, fruit zinc concentration was significantly impacted by both potassium and zinc, with combination treatments exhibiting the most gains.

Discussion:

The results of this study show that foliar treatment of zinc and potassium greatly enhanced *Olea europaea* L. cv. "Sorani" vegetative development, yield, and fruit quality. Potassium's physiological roles in plant water control, photosynthesis, and assimilate translocation are compatible with the increased vegetative responses shown with potassium administration at 1.5 and 3 ml L^{-1} . Improved turgor pressure and cell expansion, two crucial processes that allow for more effective light interception and biomass accumulation, are responsible for the notable increase in leaf area and dry matter [31]. In contrast, zinc treatment did not significantly increase vegetative growth indices. This is probably because zinc is not a key driver of biomass synthesis, but rather a cofactor in enzymatic pathways. However, the rise in leaf zinc content shows that foliar sprays are well absorbed and penetrated, proving that foliar zinc is appropriate for addressing nutritional shortages [32].

Both potassium and zinc play significant roles in reproductive development, as evidenced by the increases in yield parameters, such as fruit fresh and dry weight, fruit length, and fruit diameter. The bigger and heavier fruits obtained at 3 ml L^{-1} can be explained by potassium's enhancement of phloem loading and the transport of sugars and photosynthates to growing fruits [33]. Zinc contributes to auxin biosynthesis and enzymatic activity, promoting fruit cell division and expansion [34]. The combined $3 \text{ ml L}^{-1} \text{ K} \times 1.5 \text{ g.l}^{-1} \text{ Zn}$ treatment showed a robust synergistic response, indicating that the two nutrients' complementary physiological roles allow for the best possible fruit growth and development. On the other hand, the low yield in the absence of both nutrients emphasizes how harmful nutritional deficiencies are to reproductive activities [35].

The fertilizer sprays also had a favorable impact on fruit quality metrics including oil percentage, total soluble solids, and mineral content. greater enzyme activation, greater carbohydrate absorption, and higher energy available for lipid production might all account for the notable rise in oil % following potassium and zinc treatments [36]. Zinc appears to have a more direct function in sugar metabolism and carbohydrate transformation pathways, as evidenced by the substantial effect of zinc on TSS compared to the non-significant effect of potassium [37]. Fruits with combination treatments had the greatest levels of potassium and zinc, demonstrating the ability of foliar feeding to quickly enhance nutritional status and fruit quality.

The extent of the reaction to foliar nutrition may have been impacted by Sulaimaniyah's climate, which is marked by hot, dry summers and little rainfall throughout the growth season. Low soil moisture and excessive

evapotranspiration frequently limit soil nutrient mobility and root absorption in such semi-arid environments[38]. By avoiding soil-related constraints, foliar treatment offers a direct and effective way to supply nutrients to the canopy[39]. Therefore, the robust responses seen in this study are consistent with the environmental context, where foliar sprays probably mitigated hidden deficits made worse by high temperatures and drought stress [40]. Fruit expansion and oil buildup were among the crucial developmental stages that coincided with the application period, which started on July 3 and was repeated at suitable intervals. This timing is important because zinc requirements grow during times of vigorous metabolic activity and enzyme production, whereas potassium requirements rise during fruit filling. Therefore, precise timing that matched the tree's physiological demands and maximized nutrient absorption and utilization may be responsible for the success of foliar sprays at this time[41]. Natural variability among perennial crops cannot be totally removed, even though the study used uniform 15-year-old trees chosen for comparable size and health. Variations in root system design, microclimatic exposure, and canopy structure may affect physiological reactions and nutrition absorption [42]. Nevertheless, these effects were reduced and accurate treatment difference detection was guaranteed by the adoption of a factorial randomized full block design with three replications. The validity of the results was not compromised by variability, as evidenced by the consistency of response patterns across replications.

Although the "Sorani" cultivar was the only focus of this study, the physiological functions of zinc and potassium are common to all olive species, indicating that other cultivars could also benefit from these elements. However, cultivars like Arbequina, Koroneiki, or Frantoio may differ in their genetic composition, fertilizer needs, and fruiting habits, which might affect how sensitive they are. For comparable increases, cultivars with higher oil content or quicker growth rates can need different nutritional thresholds. Therefore, more study on other cultivars is required to generalize these suggestions across other olive-growing systems, even if the results offer a solid framework for improving foliar nutrition in Sorani olives.

Conclusion

This study demonstrated that foliar application of potassium and zinc significantly improves the growth, yield, and fruit quality of *Olea europaea* L. cv. "Sorani." Potassium at 3 ml.l⁻¹ and zinc at 1.5 g.l⁻¹ produced the most favorable results, enhancing fruit size, oil content, mineral composition, and overall productivity. The strong synergistic response to their combined application emphasizes the importance of balanced foliar fertilization, particularly under the semi-arid conditions of Kurdistan–Iraq, where limited soil moisture may restrict nutrient uptake. In contrast, the absence of both nutrients resulted in noticeably reduced growth, lower yield, and poorer fruit quality, demonstrating the negative impact of nutrient deficiency on olive tree performance. These findings support the recommendation of using foliar potassium and zinc as an effective management strategy to optimize the productivity and quality of Sorani olive trees.

References

- [1].Ameen AJ, Al-Hamdani KA. Effect of Chemical fertilizer, Bio-fertilizers and Jasmonic acid on the chemical content of olive trees *Olea europaea* L cultivar Surani. In AIP Conference Proceedings 2023 Dec 15 (Vol. 2862, No. 1, p. 020016). AIP Publishing LLC.
- [2].Kaniewski, D., Van Campo, E., Boiy, T., Terral, J.F., Khadari, B. and Besnard, G., 2012. Primary domestication and early uses of the emblematic olive tree: palaeobotanical, historical and molecular evidence from the Middle East. *Biological Reviews*, 87(4), pp.885-899.
- [3].Uylaşer V, Yildiz G. The historical development and nutritional importance of olive and olive oil constituted an important part of the Mediterranean diet. *Critical Reviews in Food Science and Nutrition*. 2014 Jan 1;54(8):1092-101.
- [4].Ghanbari R, Anwar F, Alkharfy KM, Gilani AH, Saari N. Valuable nutrients and functional bioactives in different parts of olive (*Olea europaea* L.)—a review. *International journal of molecular sciences*. 2012 Mar 12;13(3):3291-340.
- [5].Quiles JL, Barja G, Battino M, Mataix J, Solfrizzi V. Role of olive oil and monounsaturated fatty acids in mitochondrial oxidative stress and aging. *Nutrition reviews*. 2006 Oct 1;64(suppl_4):S31-9.
- [6].Salomone R, Ioppolo G. Environmental impacts of olive oil production: a Life Cycle Assessment case study in the province of Messina (Sicily). *Journal of cleaner production*. 2012 Jun 1;28:88-100.
- [7].Lionello P, Malanotte-Rizzoli P, Boscolo R, Alpert P, Artale V, Li L, Luterbacher J, May W, Trigo R, Tsimplis M, Ulbrich U. The Mediterranean climate: an overview of the main characteristics and issues. *Developments in earth and environmental sciences*. 2006 Jan 1;4:1-26.
- [8].Hama Rashid EH, Hama-salih FM. Effect of Humic and Salicylic Acids Foliar Application on Vegetative Growth and Fruit Quality of Olive (cv Sorani and Khadrawi). *Kufa Journal for Agricultural Science*. 2022 Jul 1;14(2).

- [9]. Rosati A, Paoletti A, Lodolini EM, Famiani F. Cultivar ideotype for intensive olive orchards: plant vigor, biomass partitioning, tree architecture and fruiting characteristics. *Frontiers in Plant Science*. 2024 Jan 25;15:1345182.
- [10]. Hu Y, Schmidhalter U. Drought and salinity: a comparison of their effects on mineral nutrition of plants. *Journal of plant nutrition and soil science*. 2005 Aug;168(4):541-9.
- [11]. Ali A, Niu G, Masabni J, Ferrante A, Cocetta G. Integrated nutrient management of fruits, vegetables, and crops through the use of biostimulants, soilless cultivation, and traditional and modern approaches—A mini review. *Agriculture*. 2024 Aug 9;14(8):1330.
- [12]. Tao W, Zeng S, Yan K, Alwahibi MS, Shao F. Effects of Boron and Zinc Micro-Fertilizer on Growth and Quality of Jujube Trees (*Ziziphus jujuba*) in the Desert Area. *Agronomy*. 2024 Apr 3;14(4):741.
- [13]. Karthika KS, Rashmi I, Parvathi MS. Biological functions, uptake and transport of essential nutrients in relation to plant growth. In *Plant nutrients and abiotic stress tolerance 2018 Jun 2* (pp. 1-49). Singapore: Springer Singapore.
- [14]. Haberman A, Dag A, Shtern N, Zipori I, Erel R, Ben-Gal A, Yermiyahu U. Long-term impact of potassium fertilization on soil and productivity in intensive olive cultivation. *Agronomy*. 2019 Sep 9;9(9):525.
- [15]. Kuzin A, Solovchenko A. Essential role of potassium in apple and its implications for management of orchard fertilization. *Plants*. 2021 Nov 29;10(12):2624.
- [16]. Kaur H, Devi KS, Yadav R. Physiological Significance of Zinc for Plants, Animals, and Humans. In *Zinc in Soil-Plant Continuum 2025 May 11* (pp. 33-62). Singapore: Springer Nature Singapore.
- [17]. Suganya A, Saravanan A, Manivannan N. Role of zinc nutrition for increasing zinc availability, uptake, yield, and quality of maize (*Zea mays* L.) grains: An overview. *Commun. Soil Sci. Plant Anal*. 2020 Aug 21;51(15):2001-21.
- [18]. Türkeş M, Şahin S. Will Olive Groves have a Future Under Climate Change Conditions in The North Aegean Sub-Region, a Mediterranean Agricultural Ecosystem of Türkiye?. *Turkish Journal of Agriculture-Food Science and Technology*. 2025 Jan 18;13(1):43-58.
- [19]. Najmaddin PM, Whelan MJ, Balzter H. Estimating daily reference evapotranspiration in a semi-arid region using remote sensing data. *Remote Sensing*. 2017 Jul 29;9(8):779.
- [20]. KhM AR, Khalaf-Allah AM. Design and analysis of agricultural experiments. Dar Al-Kutub Foundation for Printing and Publishing. University of Mosul. Iraq. 2000:81.
- [21]. SAS Institute. SAS Certification Prep Guide: Advanced Programming for SAS9. SAS Institute; 2015 Jan 9.
- [22]. Manas P, De las Heras J. Nutrient content in olive leaves through sustained irrigation with treated wastewater. *Scientia Horticulturae*. 2024 Apr 15;330:113084.
- [23]. Awang Y, Shaharom AS, Mohamad RB, Selamat A. Chemical and physical characteristics of cocopeat-based media mixtures and their effects on the growth and development of *Celosia cristata*. *American journal of agricultural and biological sciences*. 2009;4(1):63-71.
- [24]. Rohi Vishekaii Z, Soleimani A, Fallahi E, Hasani A, Ghasemnezhad M. Response of olive (*Olea europaea* L.) trees to foliar spray of nano chelated and chemical potassium fertilizers. *Journal of Plant Nutrition*. 2023 Apr 21;46(7):1159-71.
- [25]. Manas P, De las Heras J. Nutrient content in olive leaves through sustained irrigation with treated wastewater. *Scientia Horticulturae*. 2024 Apr 15;330:113084.
- [26]. Bayano-Tejero S, Karkee M, Rodríguez-Lizana A, Sola-Guirado RR. Estimation of harvested fruit weight using volume measurements with distance sensors: A case study with olives in a big box. *Computers and Electronics in Agriculture*. 2023 Feb 1;205:107620.
- [27]. Al-Hamamre Z. Biodiesel production from olive cake Oil. Amman: Chemical Engineering Department, Faculty of Engineering and Technology, University of Jordan. 2011;11942.
- [28]. Bender I, Moor U, Luik A. Plant Biochemistry of the Estonian University of Life Sciences. Before and after storage, the total soluble solids (TSS) content (Brix) was measured using the digital refractometer ATAGO CO., Ltd., Japan and β -carotene. *Research for Rural Development*. 2015:119.
- [29]. Saleh DS, Ahmad ST, Kareem SR. Determination of the potassium content in fruit samples by gamma spectrometry to emphasize its health implications. *ARO-THE SCIENTIFIC JOURNAL OF KOYA UNIVERSITY*. 2022 Oct 20;10(2):62-72.
- [30]. Liu M, Yu H, Liu L, Ma Z, Zhou J, Tang S, Wu L, Fu G, Li Y, Xu M. Evaluation of Zinc Concentrations in Fruit from Various Pear Strains and Cultivars in China for Establishing a Standard for Zinc-Enriched Pears. *Horticulturae*. 2023 Oct 19;9(10):1148.
- [31]. Vishekaii, Z., Soleimani, A., Fallahi, E., Hasani, A., & Ghasemnezhad, M. (2022). Response of olive (*Olea europaea* L.) trees to foliar spray of nano chelated and chemical potassium fertilizers. *Journal of Plant Nutrition*,

- 46, 1159–1171. <https://doi.org/10.1080/01904167.2022.2072740>.
- [32]. Gammal, O. (2022). Effect of Zinc and Boron on Vegetative Growth, and Fruiting of Manzanillo Olive Tree under Siwa Oasis Conditions. Alexandria Science Exchange Journal. <https://doi.org/10.21608/asejaigsae.2022.278625>.
- [33]. Liesche, J. (2016). How regulation of phloem transport could link potassium fertilization to increased growth. Tree physiology, 36(1), 1-5.
- [34]. Zhang, Y., Yan, Y., Fu, C., Li, M., & Wang, Y. A. (2016). Zinc sulfate spray increases activity of carbohydrate metabolic enzymes and regulates endogenous hormone levels in apple fruit. Scientia Horticulturae, 211, 363-368.
- [35]. L., Rana, G., & , S. (2024). The Effect of Foliar Application of Zinc, Potassium, and Boron on Fruit Set and Retention in Kinnow Mandarin. Asian Journal of Soil Science and Plant Nutrition. <https://doi.org/10.9734/ajsspn/2024/v10i4434>.
- [36]. Sawan, Z. M., Hafezb, S. A., Basyony, A. E., & Alkassas, A. E. E. R. (2007). Cottonseed: protein, oil yields, and oil properties as influenced by potassium fertilization and foliar application of zinc and phosphorus. Grasas y aceites, 58(1), 40-48.
- [37]. Perumal, M., Subramanian, V., & Sabarinathan, K. (2017). Evaluation of Zinc Solubilizing Potential of Maize Rhizosphere Bacterial Isolates. International Journal of Current Microbiology and Applied Sciences, 6, 864-869. <https://doi.org/10.20546/ijcmas.2017.612.093>.
- [38]. Chi, Y., Ali, S., Lin, J., Yang, L., & Zhou, X. (2026). Soil moisture and nutrient mobility influence nitrogen partitioning and translocation in maize (*Zea mays* L.) under various water-nitrogen regimes. European Journal of Agronomy, 173, 127914.
- [39]. Patyal, D., Ali, A., Mukhtar, S., Devi, M., Mansoor, T., Khajuria, A., & Kaur, G. (2024). Foliar Application of Micronutrients in Orchards: A Comprehensive Review. International Journal of Plant & Soil Science, 36(11), 426-440.
- [40]. Ray, S., Maitra, S., Sairam, M., Sravya, M., Priyadarshini, A., Shubhadarshi, S., & Padhi, D. P. (2024). An unravelled potential of foliar application of micro and beneficial nutrients in cereals for ensuring food and nutritional security. Int. J. Exp. Res. Rev, 41, 19-42.
- [41]. Lovatt, C. J. (2013). Properly timing foliar-applied fertilizers increases efficacy: A review and update on timing foliar nutrient applications to citrus and avocado. HortTechnology, 23(5), 536-541.
- [42]. Balliu, A., Zheng, Y., Sallaku, G., Fernández, J. A., Gruda, N. S., & Tuzel, Y. (2021). Environmental and cultivation factors affect the morphology, architecture and performance of root systems in soilless grown plants. Horticulturae, 7(8), 243.

تأثير أشجار الزيتون صنف صوراني في الرش الورقي بأسمدة البوتاسيوم والزنك

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الخلاصة

تم تقييم تأثيرات الرش الورقي بكل من البوتاسيوم والزنك في النمو الخضري والإنتاجية وجودة ثمار *Olea europaea* L. صنف "صوراني" في تجربة حقلية نُفذت في بركجو، السليمانية، إقليم كردستان-العراق، خلال موسم النمو لعام 2024. استُخدمت أشجار زيتون بعمر خمسة عشر عامًا مزروعة بتباعد 4 × 4 أمتار، ورتبت وفق تصميم القطاعات العشوائية الكاملة العاملية بثلاث مكررات. وتم اختيار سبعة وعشرين شجرة متماثلة في الحجم والحالة الصحية وتوزيعها على تسع معاملات مكونة من ثلاثة تراكيز من البوتاسيوم (0، 1.5، و 3 مل لتر □¹) وثلاثة تراكيز من الزنك (0، 1.5، و 3 غ لتر □¹)، حيث طُبِّقَت الرشوات الورقية ثلاث مرات ابتداءً من 3 تموز 2024. أظهرت النتائج أن تطبيق البوتاسيوم أدى إلى تحسن معنوي في الصفات الخضريّة، بما في ذلك مساحة الأوراق والوزن الجاف للأوراق وتركيز البوتاسيوم فيها، في حين أسهم الزنك بشكل رئيسي في زيادة تركيز الزنك في الأوراق. كما استجابت مكونات المحصول مثل الوزن الطازج والجاف للثمار وطول الثمرة وقطرها باستجابات إيجابية معنوية لكلا العنصرين، مسجلة أعلى القيم عند 3 مل لتر □¹ بوتاسيوم و 1.5 غ لتر □¹ زنك. وازدادت الإنتاجية الكلية للشجرة بشكل ملحوظ تحت هذه المعاملات، وحققَت المعاملة المشتركة 3 مل لتر □¹ بوتاسيوم × 1.5 غ لتر □¹ زنك أعلى إنتاجية بلغت 9.57 كغ شجرة □¹. كما تحسنت صفات جودة الثمار، إذ ازداد كل من نسبة الزيت وتركيز الزنك في الثمار معنويًا مع الرش الورقي بالزنك، بينما زاد البوتاسيوم من تركيز البوتاسيوم في الثمار. واستجابت المواد الصلبة الذائبة الكلية (TSS) للزنك بشكل معنوي، في حين لم يتأثر بها البوتاسيوم. وبشكل عام، سجّلت المعاملات الخالية من كلا العنصرين أقل القيم لجميع القياسات، مما يدل على التأثير السلبي الواضح لنقص العناصر الغذائية. وتخلص الدراسة إلى أن الرش الورقي بالبوتاسيوم والزنك—ولا سيما عند تركيزي 3 مل لتر □¹ و 1.5 غ لتر □¹ على التوالي—يعزز بشكل كبير النمو والإنتاجية وجودة الثمار لشجر الزيتون صنف "صوراني" في مناخ كردستان شبه الجاف.

الكلمات المفتاحية: *Olive* ، البوتاسيوم، الزنك، الرش الورقي، الإنتاج..