

# Influence of Foliar Spraying with Macro and Microelements on the Growth and Productivity of Olive Trees in Idleb Province

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**Abstract** - In this research, the effect of foliar spraying, with macro and microelements on the productivity of Sourani olive variety, was studied in Arab-Said village (which is 5 km west of Idleb), during the years 2012-2013. A randomized block design was used, and 4 treatments were performed, each of which contained 5 replicates, each replicate was one olive tree. During the experiment, foliar spraying was applied with a mix of macro and microelements, so that the treatments differed between them by the number of sprayings (0, 1, 2, and 3) and their dates (before flowering, one week after flowering, and two weeks after the second spraying). The results showed that all foliar spraying treatments outperformed the control, with a significant increase, in most of the indicators and parameters studied: the leaf surface (2.41 cm<sup>2</sup>), the number of flowering cluster/branch (13.32), the number of flowers/flowering clusters (8.88), the number of flowers/branch (359.2), the percentage of fruit-set (0.61%), the number of fruits/branch (24.41), the fruit weight (0.98 g), the fruit size (0.49 mL), and pulp/fruit ratio (3.43%). Where spraying once before flowering had the most significant increase compared to other spraying treatments. While the increase in the number of spraying times did not have any significant effect on the previous indicators, it led to a significant increase in the vegetative growth index (6.75cm), in the productivity/tree (39.42 kg), and in the percentage of oil (5.28%), compared to the control. Finally, the results showed that production varied greatly between the two years of the study (the phenomenon of alternate-bearing), but that all experimental treatments reduced this difference comparing to the control.

**Keywords:** Olive Tree, Foliar Spraying, Macro & Microelements, Vegetative Growth, Productivity.

## I. INTRODUCTION

The olive tree (*Olea europaea*L.) is a perennial tree belonging to the Oleaceae family. Sometimes it reaches 15 meters in height and survives more than 1000 years. Many researchers point out that Syria is the origin of the olive tree, as

wild olives are still spread in many areas (Aswad *et al.*, 1993; Al-Deiri, 2003). It is estimated that there are about 800 million olive trees on the surface of the earth currently, belonging to more than 400 species and spread in an agricultural area of more than 10 million hectares, and about 98% of the olive trees are concentrated in the Mediterranean countries (El-Badri and Dawoud, 2004, FAO, 2017). Syria ranks seventh in the world in olive production with about 750,000 tons, and Idleb Governorate comes at the forefront of the olive producing governorates in Syria (CSO, 2019).

Providing mineral nutrition is one of the important means of improving the productivity and quality of fruits (Tagliavini *et al.*, 2002). Most studies indicated a positive response to olive productivity by increasing mineral nutrition (Talaie and Taheri, 2001; Ben-Rouina *et al.*, 2002). Research also shows that fertilizing with mineral elements such as potassium and calcium that increase the toughness of membranes and cell walls, helps the plant increase its resistance to environmental stresses such as drought and water stress (Gao *et al.*, 1999; Li *et al.*, 2003). Ran *et al.* (2008) indicate that all macro elements play a key role in the processes that affect olive tree productivity, and that the availability of NPK elements has an effect on increasing the density of flowers in olive trees. Ben-Khelil (2010) stated that fertilization with compound fertilizers from NPK has improved vegetative growth in olive trees. Ragab (2002) reported an increase in productivity when spraying trees with macro elements.

In addition to the macro elements, olive trees require minor amounts of boron, zinc, iron, manganese, copper, and molybdenum. Whereas, Perica *et al.* (2001) mentioned that spraying with microelements increased the productivity of olive trees. When there is a shortage of these elements, there can be a decrease in the growth and fruit of the olive tree (Kailis and Harris, 2007). Likewise, flowering and fruit-set are affected, directly or indirectly, by the mineral state by their effect on other physiological processes in the tree (Fabbri and Benelli, 2000). When sufficient quantities of macro and microelements are not provided, there is a large fall of flowers

after two weeks of full bloom in olives (Martin, 1990; Pinney and Polito, 1990a, b; Rapoport and Rallo, 1991). So, there is a need to provide sufficient quantities of macro and microelements during the flowering and fruit-set stages that are among the main stages affecting production, especially in olives, as there is suffering from the phenomenon of alternate bearing (Martin *et al.*, 2005; Lavee, 2006). Also, there are many complete flowers that fall at different periods of growth of the fruit, and the reason for its fall is the competition on food that occurs between the fruits themselves and with other active organs in the tree (Brooks, 1948; Rallo and Fernandez-Escobar, 1985; Rapoport and Rallo, 1991; Fernandez-Escobar *et al.*, 1992).

Recent studies have tended, to compensate for the lack of nutrients in the soil, to use the foliar spraying technique with macro and microelements, as it is one of the most efficient methods of fertilization, as its efficiency is estimated at 8-20 times compared to adding it through the soil. Also it is characterized by low rates of use, the rapid response to the nutrient application, and the homogeneous distribution of nutrients. In addition, in cases of invisible deficiencies, can be easily controlled by applying foliar fertilization (Peukeet *al.*, 1998; Umeret *al.*, 1999; Gonzalez *et al.*, 2010). Foliar spraying is a good solution especially in dry areas where little rain and lack of water in summer reduce mineral absorption significantly by trees (Ben-Mimounet *al.*, 2004). Moreover, foliar fertilization reduces the accumulation of nutrients in the soil, their fixation in the soil, their loss in groundwater, causing salinity and nitrate contamination and thereby reducing the negative consequences for humans and the environment (Swietlik and Faust, 1984; Römheld and El-Fouly, 1999). Foliar spraying plays an important role in improving the characteristics of the vegetative growth of the plant and increasing productivity, resisting insects and diseases, enhancing resistance to drought, and improving the quality of fruits (Joe, 2006). The response of crops depends on the varieties, and on the period and concentration of spraying, as well as the stage of plant growth (Al-Sahaf, 1989; Al-Bayoumi *et al.*, 2000; Kuepper, 2003).

In a study by Shahan (1995) to see the effect of foliar spraying with some nutrients on the flowering and productivity of olive trees, they were observed that foliar spraying with some of these elements in the form of zinc sulfate, boric acid, magnesium sulfate, and manganese sulfate resulted in a clear increase in flowering intensity, and increased the percentage of hermaphrodite flowers, production of pollen, the percentage of the fruit-set, the global yield, as well as the percentage of oil in the fruits. Ramezani and Shekafandeh (2009) stated that the application of foliar spraying increased the weights of fruits and seeds and increased the pulp/fruit ratio in the Shengeh olive cultivar. Also, the application of foliar fertilization in the

olive orchards increased the size of fruits (Topluet *al.*, 2009). According to Morales-Sillero *et al.* (2008), the pulp thickening, the dry weight, and the dimensions of the fruit, and the proportion of pulp/fruit increased by using the macroelements.

El-Khawaga *et al.* (2007) stated that foliar spraying with macro and microelements resulted in a significant increase in the fruit content of oil in the Manzanillo olive variety. As the accumulation of oil in olive fruits is a process that depends on the amount of carbohydrates produced from the fruits and old leaves (Conde *et al.*, 2008). Ben-Khelil and Mustapha (2013) conducted a three-year research 2006, 2007, 2008 on Arbequinaolive variety, during which they found that fertilization had an effect on improving global productivity compared to the control, as the content of oil in fruits increased during the three years. This increase is due to the improvement of the nutritional status of macro and microelements as a result of adding fertilizers in appropriate quantities and during the sensitive physiological stages of growth and development of olive trees.

Abbasiet *al.* (2012) conducted a study with the aim of knowing the effect of fertilizing with macro and microelements, individually or in combination, on the quantity and quality of production for the olive varieties Zard and Rowghani. The results showed that foliar spraying with macro and microelements had a very significant effect in increasing the weight of the fruits as well as the weight of the pulp and led to a significant increase in productivity in both cultivars compared with the control. To find out the effect of fertilization on the leaf content of some nutrients, Jordao (1994) conducted an experiment on the Galega olive variety in Portugal, as the soil was fertilized over four years by the basic elements NPK as well as the micronutrients Mn, Fe, Zn, Cu, B, Mo, and Mg, sprayed on leaves. The results showed that the leaf content of nitrogen increased during the high bearing years and the low bearing years, in addition to the lack of potassium during the low bearing years. In general, in the low bearing years, the leaf content of NPK was higher during the season, while the leaf content of Mg and Ca was different during the high bearing years compared to the low bearing years.

The foliar spraying process has great importance for olive trees. However, there is insufficient information available about the dates for the foliar spraying, the appropriate quantities of macro and microelements, and the number of sprays appropriate to improve the growth and productivity of this tree. Therefore, this research was conducted with the aim of studying the effect of foliar spraying with a mix of macro and microelements on the growth and production indicators in the olive tree and determining the optimum number and date for spraying.

## II. MATERIALS AND METHODS

### 2.1 Experiment Location

This research was conducted during the years 2012 and 2013 in an olive orchard in the village of Arab-Said, which is about 10 km to the west of Idleb city. It follows the Mediterranean semi-arid climate and the medium-cold temperature. Whereas the general rain rate for the previous ten years 450 mm, according to the rainy bulletin issued by the Directorate of Agriculture and Agrarian Reform in Idleb Governorate, but during the two research years the average did not exceed 300 mm on average.

### 2.2 Plant material

The orchard is planted with olive trees of Sourani variety, at a distance of 10x10 m. It is homogeneous in size, with a height of about 5 m, and with a close lifespan of about 30 years. Sourani variety is considered one of the finest cultivars cultivated in Syria and it is characterized by its being dual purpose, its tree is medium size taking the spherical shape. Its fruits are medium-sized, elongated, light green with a red shine and become black at maturity. It has a high oil content (28-30%). It is used for green and black pickling and is desirable for marketing. It is excellent resistance to olive knot disease, leg diggers and peacock's eyespot (Al-Bakeer, 2005).

### 2.3 Experimental treatments

The service, agriculture, pruning, and pest control operations were applied uniformly to all treatments. According to the recommendations of the Agricultural Scientific Research Center in Idleb, the following fertilizer quantities/dunum were added: 54 kg of urea fertilizer, 26 kg of superphosphate fertilizer and 3 m<sup>3</sup> of organic fertilizer decomposed during the years of study, with the same level over the entire land area, in order to standardize the treatments in terms of the effect of the soil fertilizer applied during the research years.

Foliar spraying with macro and microelements was applied to the trees of treatments in this orchard. A soluble fertilizer (Nitrofoska) solution (1.5 g /L water) was used which is composed of fertilizer elements as shown in Table (1). Foliar spraying was done using a dorsal sprinkler, and the spraying process continued until the treatment trees were completely wet (5 L/tree), in the early morning period.

TABLE 1  
Composition of Nitrofoska fertilizer used in the research

Element	(%)	Element	(%)
NH <sub>4</sub>	15	Mn	0.04
P <sub>2</sub> O <sub>5</sub>	30	Cu	0.015

K <sub>2</sub> O	15	B	2.0
MgO	0.8	Fe	0.04
S	4.8	Zn	0.015
		MO	0.001

The experimental treatments differed between them according to the number of sprays and their dates, as shown in Table (2).

TABLE 1  
Experimental Transactions

Treatment	Number of sprays	Date of spraying
1	0	Control
2	1	One before flowering
3	2	1 <sup>st</sup> before flowering; 2 <sup>nd</sup> after flowering
4	3	1 <sup>st</sup> before flowering; 2 <sup>nd</sup> after flowering; 3 <sup>rd</sup> 15 days after second

### 2.4 Measured parameters

**Vegetative growth parameters:** Annual vegetative growth/branch (cm): 10 recent branches were taken on the perimeter of each studied tree, the start of which was determined from the last old leaf of the previous year, and serial numbers were given and strips were placed on them in different colors as a markers in order to calculate the annual vegetative growth rate. Leaf surface (cm<sup>2</sup>): This trait was studied on a sample of 40 leaves taken from the middle part of 10 branches one-year-old using the following formula:

$$\text{Foliar surface (cm}^2\text{)} = [0.53 \times \text{leaf length (cm)} \times \text{leaf width (cm)}] + 1.66$$

**Indicators of flowering and fruit-set:** The start of blooming buds was determined when 10% of the flowers bloom, 10 recent branches was taken on the perimeter of each tree studied in different directions, and bars with different colors were placed on them as a marker for each branch. The number of flowering clusters per branch, the number of flowers per flowering cluster, and the number of flowers per branch were calculated. Also, the number of formed fruits per branch was recorded four weeks after full flowering and the percentage of the fruit-set was calculated.

**Characteristics of the fruit:** 10 recent branches were taken on the perimeter of each tree studied and in different directions, strips of different colors were placed on them as a marker for each branch, and the number of remaining fruits was recorded on each branch. Also, the weight of the fruit (g) was calculated using a sensitive balance, and the volume of the fruit (mL) was calculated by using the listed cylinder and calculating the amount of water displaced from the position of the fruits inside the cylinder. Then, after the weight of each fruit, the seed was weighed to calculate the pulp/fruit ratio.

**Productivity parameters:** Productivity (kg/tree): the harvest was done manually on November 5 of each year. After

collecting the production of each tree and removing the leaves, branches, soil, and impurities present among the olive fruits, the fruits of each tree were weighed with a normal scale, and then the average for each treatment (5 replications) was calculated. Oil percentage (%): A sample of 40 fruits was taken from the middle part of the fruiting branch and from all sides. An amount of 2 kg of olive fruits was collected from each tree and the oil was extracted on the basis of wet weight by a special olive press in the laboratories of the Olive Research Center in Idleb.

### 2.5 Experimental design

A complete randomized block design was used. Five spraying treatments (0, 1, 2, 3, spraying times) were applied. Five replicates per treatment, with one tree (Saurani olive variety) per replicate were adopted. Consequently, the number of olive trees used in the experiment = 4 treatments x 5 replicates x 1 tree = 20 trees.

### 2.6 Statistical analysis

The results were statistically analyzed using the GENSTAT -12 SPSS-18 software to find the significance of the differences with the ANOVA method and extract the least significant difference (LSD) at the level of 5%. The work and analysis of samples were carried out in the laboratories of the faculty of agricultural engineering at the University of Idleb.

## III. RESULTS AND DISCUSSION

### 3.1 The effect of foliar spraying on vegetative growth

Through our study of the effect of foliar spraying with macro and microelements on the annual vegetative growth of the branch, we attained the results displayed in Table (3).

TABLE 2  
The effect of foliar spraying on vegetative growth

Treatment	Vegetative growth of branch (cm)			Leaf surface (cm <sup>2</sup> )		
	2012	2013	Average	2012	2013	Average
1	8.73	11.69	10.21 <sup>ds</sup>	4.14	4.60	4.37 <sup>bs</sup>
2	10.66	16.81	13.74 <sup>c</sup>	6.40	7.16	6.78 <sup>a</sup>
3	12.18	18.52	15.35 <sup>b</sup>	6.69	7.26	6.98 <sup>a</sup>
4	13.70	20.22	16.96 <sup>a</sup>	6.58	7.45	7.02 <sup>a</sup>
LSD (0.05)	1.099			0.48		

\* in the same column, the values share one letter, there is no significant difference between them

#### 3.1.1 Annual vegetative growth of branch (cm)

From Table (3), which shows the results of applying foliar spraying with macro and microelements on the annual vegetative growth of the branch, it appears that all spraying

treatments (2, 3, and 4) outperformed the control with significant differences. Where the second treatment achieved an increase of 3.53 cm on the control. The third treatment achieved an increase of 5.14 cm on the control. While the fourth treatment achieved an increase of 6.75 cm on the control. Also, the increase in the number of spraying had a significant effect on increasing the annual vegetative growth of the branch. As the third treatment (two foliar sprayings) achieved an increase in the vegetative growth, reaching 1.61 cm on the second treatment (one foliar spraying). The fourth treatment (three foliar sprayings) achieved an increase in the vegetative growth of 1.61 cm on the third treatment (two foliar sprayings), Figure (1).

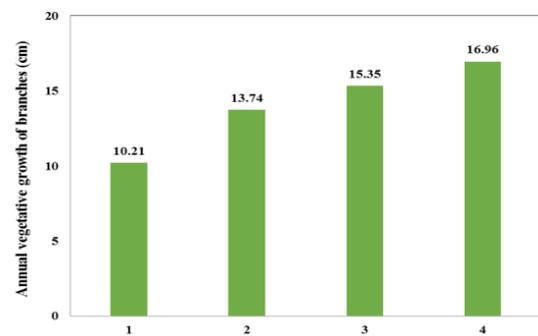


Figure 1: The effect of foliar spraying on the annual vegetative growth of branch

These results illustrate the positive effect of foliar spraying with macro and microelements on the vegetative growth of branches. This effect can be explained by improving the nutritional status of trees and thereby stimulating metabolism in the treated trees and thus improving their vegetative growth. Our results are in agreement with many studies that have shown the importance of foliar spraying with macro elements in increasing vegetative growth and increasing the growth of branches of olive trees. As it increases chlorophyll in the leaves and thus photosynthesis and thus enhances the growth of the branches (Abu-Dahi and Al-Yunus, 1988; Al-Khaffaji *et al.*, 1990; Al-Bayoumi *et al.*, 2000; Al-Douri and Al-Rawi, 2000; Perry and Hiekman, 2000; Ben-khelil, 2010; Muhammad *et al.*, 2012). On the other hand, some studies have confirmed the role of foliar spraying with microelements in stimulating the growth of olive trees. These elements play an important role in stimulating biosynthesis through the accumulation of elements and organic hormones (Yagodin, 1989; Joe, 2006; Xiao *et al.*, 2010; Muhammad *et al.*, 2012).

#### 3.1.2 Leaf surface (cm<sup>2</sup>)

It appears from Table (3), which shows the results of applying foliar spraying with macro and microelements in the leaf surface, all spraying treatments (2, 3, and 4) outperformed

the control with significant differences. Where the second treatment achieved an increase of 2.41 cm<sup>2</sup> on the control. While the increase in the number of foliar sprayings (two sprayings in the third treatment or three sprayings in the fourth treatment) did not lead to a significant increase in the leaf surface compared to the one-time spraying (the second treatment), Figure (2).

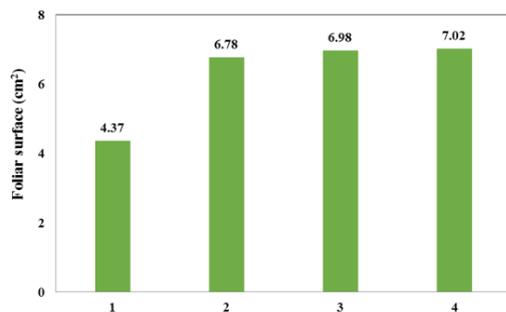


Figure 2: The effect of foliar spraying on the leaf surface

These results demonstrate the positive effect of foliar spraying with macro and microelements in causing a

significant increase in the leaf surface. This effect can be explained by the better availability of nutrients and their rapid absorption by the leaves, thereby increasing the rate of photosynthesis and also due to the integration of the roles of these elements together, which contributed to the increase in cell division and elongation and thus the increase in the leaf surface (Gonzalez *et al.*, 2010). Our results are consistent with many studies that have shown the role of foliar spraying in increasing the leaf surface on many agricultural crops such as almonds (Saeed *et al.*, 2000), pomegranate (Hegazi *et al.*, 2002), grapes (Al-Tahafi, 2006), strawberries (Kanash and AL-Sheikh, 2013), chinese ester (Idan, 2014), gerbera (Sahi, 2005), and olive (Al-Zubaidi, 2003).

### 3.2 The effect of foliar spraying on flowering indicators

As a result of our study of the effect of foliar spraying with macro and microelements on the flowering indicators (number of flowering clusters/branch, number of flowers/flowering cluster, number of flowers/branch, and fruit-set), we obtained the results presented in Table (3).

TABLE 3  
The effect of foliar spraying on flowering indicators

Treatment	Flowering-clusters /branch			Flowers/flowering cluster			Flowers/branch			Fruit-set (%)		
	2012	2013	Average	2012	2013	Average	2012	2013	Average	2012	2013	Average
1	16.08	6.50	11.29 <sup>b*</sup>	14.75	8.42	11.59 <sup>b*</sup>	237.18	54.73	145.96 <sup>b*</sup>	5.95	6.21	6.08 <sup>b*</sup>
2	27.67	21.54	24.61 <sup>a</sup>	23.10	17.23	20.17 <sup>a</sup>	639.18	371.13	505.16 <sup>a</sup>	6.24	7.13	6.69 <sup>a</sup>
3	27.38	22.33	24.86 <sup>a</sup>	23.08	17.33	20.21 <sup>a</sup>	631.93	386.98	509.45 <sup>a</sup>	6.46	7.28	6.87 <sup>a</sup>
4	27.62	22.92	25.27 <sup>a</sup>	23.25	17.42	20.34 <sup>a</sup>	642.17	399.27	520.72 <sup>a</sup>	6.47	7.29	6.88 <sup>a</sup>
LSD (0.05)	1.081			0.849			20.84			0.329		

\* in the same column, the values share one letter, there is no significant difference between them

#### 3.2.1 Number of flowering clusters/branch

It can be seen from Table (4), which shows the effect of foliar spraying with macro and microelements on the number of flowering clusters/branch, that all foliar spraying treatments (2, 3, and 4) were superior to the control, with significant differences. Whereas the number of flowering clusters/branch in the second treatment was more than twice that of the control (2.18 times).

While there were no significant differences between the spraying treatments themselves and the increase in the number of sprayings did not affect the increase in the number of flowering clusters than that achieved by one spraying before flowering, Figure (3).

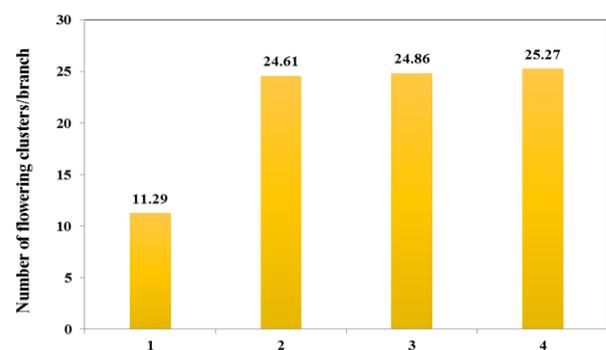


Figure 3: The effect of foliar spraying on the number of flowering clusters/branch

#### 3.2.2 Number of flowers/flowering clusters

From Table (4), which clarifies the effect of foliar spraying with macro and microelements on the number of flowers/flowering cluster, we note that all treatments of foliar spraying (2, 3, and 4) outperform the control with significant differences, as the number of flowers/flowering cluster nearly doubled in the second treatment compared to the control (1.74

times), while there were no significant differences between the spraying treatments themselves, and the increase in the number of spraying times did not affect the increase in the number of flowers/flowering cluster than that achieved by one spraying, Figure (4).

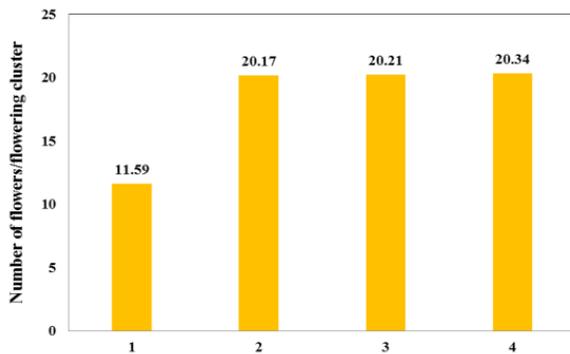


Figure 4: The effect of foliar spraying on the number of flowers/flowering cluster

### 3.2.3 Number of flowers/branch

It is noted from Table (4), that explains the effect of foliar spraying with macro and microelements on the number of flowers/branch, that all treatments of foliar spraying (2, 3, and 4) outperformed the control with significant differences, as the number of flowers/branch tripled in the second treatment compared to the control (3.46 times), while there were no significant differences between the spraying treatments themselves, and the increase in the number of spraying times did not affect the increase in the number of flowers/branch than that achieved by one spraying, Figure (5).

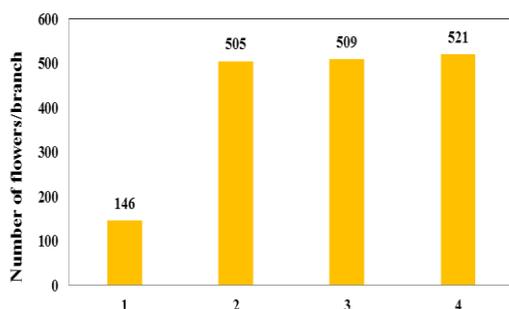


Figure 5: The effect of foliar spraying on the number of flowers/branch

### 3.2.4 Fruit-set (%)

It is noted from Table (4), that shows the effect of foliar spraying with macro and microelements on the percentage of fruit-set, so all the foliar spraying treatments (2, 3, and 4) outperformed the control with significant differences, whereas the second treatment (one spraying before flowering) increased

the fruit-set by 0.61% on the control, while there were no significant differences between the spraying treatments themselves, and the increase in the number of spraying times did not achieve a significant increase in the percentage of fruit-set than that attained by one spraying, Figure (6).

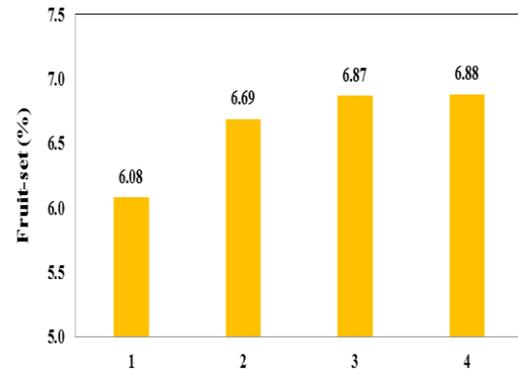


Figure 6: The effect of foliar spraying on the percentage of fruit-set

The previous results show the positive effect of foliar spraying with macro and microelements on flowering indicators (number of flowering clusters/branch, number of flowers/flowering cluster, number of flowers/branch, percentage of fruit-set). Generally, this positive effect is explained by the improvement of the nutritional status of olive trees as a result of foliar spraying and the rapid and direct use of mineral elements. Studies have confirmed that the flowering and fruiting processes are directly or indirectly affected by the mineral state in the olive trees, through their effect on other physiological processes in the tree. Also, the foliar spraying with mineral elements led to a clear increase in the percentage of fruit-set (Shahen, 1995; Fabbri and Benelli, 2000). Some studies have shown that nitrogen spraying increased the percentage of fruit-set in olive (Lavee, 1986; Cimato *et al.*, 1990; Arshad *et al.*, 2006). While Rickard (2000) showed that phosphorous spraying clearly increased the percentage fruit-set in olive. Lavee *et al.* (1996) found that the lower flowering rate was due to lower concentrations of nitrogen, phosphorous and potassium. On the other hand, boron has been shown to increase the growth and development of flowers and to improve the percentage of fruit-set by helping pollen to germinate on the stigma and to develop the pollen tube inside the style to reach the ovary and induce the fertilization (Perica *et al.*, 2001; Racsko, 2009).

### 3.3 The effect of foliar spraying on fruit characteristics

According to our study of the effect of foliar spraying with macro and microelements on fruit characteristics (number of fruits/branch, fruit weight, fruit size, pul[fruit ratio), we got the results shown in Table (3).

TABLE 4  
The effect of foliar spraying on fruit characteristics

Treatment	Fruits/branch			Fruit weight (g)			Fruit size (mL)			Pulp/fruit (%)		
	2012	2013	Average	2012	2013	Average	2012	2013	Average	2012	2013	Average
1	14.11	3.40	8.76 <sup>bc</sup>	2.14	2.52	2.33 <sup>bc</sup>	1.00	1.30	1.15 <sup>bc</sup>	80.69	82.00	81.35 <sup>bc</sup>
2	39.88	26.46	33.17 <sup>a</sup>	2.86	3.76	3.31 <sup>a</sup>	1.38	1.90	1.64 <sup>a</sup>	84.04	85.52	84.78 <sup>a</sup>
3	40.82	28.17	34.50 <sup>a</sup>	2.95	3.97	3.46 <sup>a</sup>	1.50	2.10	1.80 <sup>a</sup>	84.24	85.94	85.09 <sup>a</sup>
4	41.55	29.11	35.33 <sup>a</sup>	3.01	4.48	3.75 <sup>a</sup>	1.60	2.30	1.95 <sup>a</sup>	84.54	86.04	85.29 <sup>a</sup>
LSD (0.05)	2.67			0.45			0.32			1.068		

\* in the same column, the values share one letter, there is no significant difference between them

### 3.3.1 Number of fruits/branch

We observe from Table (5), which shows the results of foliar spraying with macro and microelements on the number of fruits/branch, that all spraying treatments (2, 3, and 4) outperformed the control with significant differences, as the second treatment achieved an increase of 24.41 fruits on the control. While the increase in the number of sprayings (2 or 3) did not achieve an additional significant effect over the effect achieved by one spraying before flowering, Figure 7.

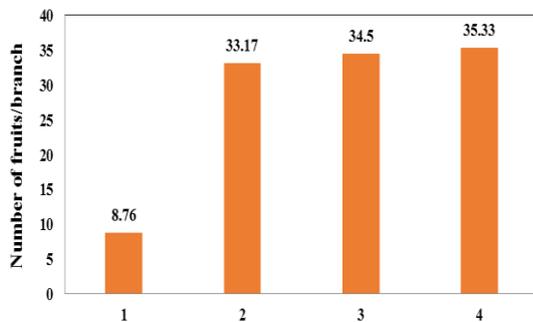


Figure 7: The effect of foliar spraying on the number of fruits/branch

### 3.3.2 Fruit weight (g)

We can find from Table (5), which shows the results of foliar spraying with the macro and microelements in the fruit weight (g), that all spraying treatments (2, 3, and 4) outperform the control with significant differences, as the second treatment achieved an increase of 0.98 g on the control. While the increase in the number of spraying times (treatments 3 and 4) did not achieve a significant increase in the weight of the fruit compared to one foliar spraying (treatment 2), Figure 8.

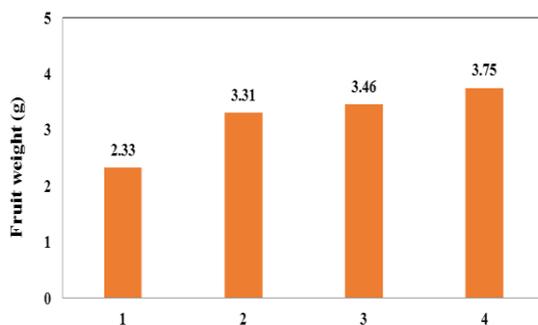


Figure 8: The effect of foliar spraying on the fruit weight

### 3.3.3 Fruit size (mL)

It appears from Table (5), which shows the results of foliar spraying with macro and microelements on the fruit size, that all spraying treatments (2, 3, and 4) outperformed the control with significant differences, as the second treatment achieved an increase of 0.49 (mL) on the control. While the increase in the number of spraying times did not lead to significant additions in the size of fruits above the value achieved by one spraying, Figure 9.

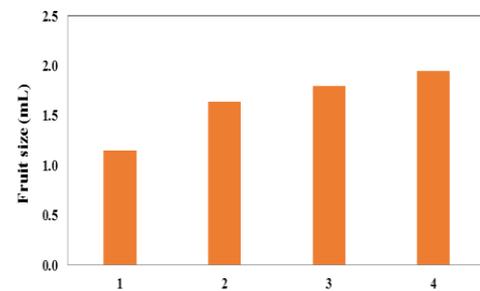


Figure 9: The effect of foliar spraying on the fruit size

### 3.3.4 Pulp/fruit ratio (%)

It seems from Table (5), which shows the results of the foliar spraying with macro and microelements on the pulp/fruit ratio (%), that all the spraying treatments (2, 3, and 4) outperformed the control with significant differences, as the second treatment achieved an increase of 3.43% on the control. However, the increase in the number of spraying times (2 in treatment 3 or 3 in treatment 4) did not achieve a significant increase over the increase achieved by one spraying (treatment 2), Figure 10.

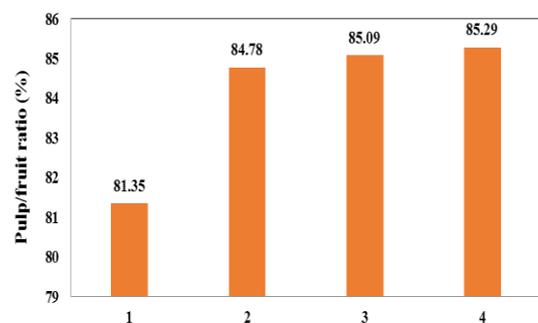


Figure 10: The effect of foliar spraying on the pulp/fruit ratio

These results show the positive effect of foliar spraying with macro and microelements in causing a significant increase on the characteristics of the fruit (number of fruits/branch, fruit weight, fruit size, and pulp/fruit ratio). The results are

consistent with many studies and researches conducted on olives, which showed that all nutrients play an important role in improving growth and fruiting by stimulating cell expansion and division (Blevins and Lukaszewski, 1998).

Abbasi *et al.* (2012), in their research with the aim of knowing the effect of fertilizing with macro and microelements (individually or in combination) on the quantity and quality of production for the two olive varieties "Zard and Rowghani", stated that foliar spraying had a large effect in increasing the weight of the fruits as well as the weight of pulp in both cultivars compared to treatment of control.

Ramezani and Shekafandeh (2009) also mentioned that the application of foliar spraying increased the weights of fruits and seeds and increased the pulp/fruit ratio in olive cultivar "Shengeh". Toplu *et al.* (2009) cited that the application of foliar spraying in olive orchard increased the size of fruits. Also, Morales-Sillero *et al.* (2008) indicated that the thickness of the pulp in the fruits, the dry weight of the fruit, the dimensions of fruit, and the pulp/fruit ratio increased using the macroelements. In research on the Picual cultivar, Sarwiy *et al.* (2010) showed that foliar spraying with potassium nitrate and potassium monophosphate has resulted in a significant increase in the length and diameter of the fruits and in the weight of the fruit and seed.

Ben-Mimoun *et al.* (2004) mentioned that potassium fertilizers lead to increased fruit weight and pulp/fruit ratio. Dikmelik *et al.* (1999) cited that the use of potassium nitrate on olive trees during the second and third stages of fruit growth improved the growth of olive fruits and obtained the best results in the size of the fruits. However, Pegah and Alireza (2010) showed that increasing the characteristics of fruits such as weight, size and dimensions are due to the different roles of zinc and potassium in physiological processes in plants.

Also, Rapoport *et al.* (2004) revealed that zinc sulfate has a positive effect on the fruit characteristics (weight and diameter) of the Shengeh olive variety.

### 3.4 The effect of foliar spraying on productivity indicators

Via our study of the effect of foliar spraying with macro and microelements on productivity indicators (productivity per tree and percentage of oil) of Sourani variety, we reached the results shown in Table (6).

TABLE 5  
The effect of foliar spraying on productivity indicators

Treatment	Productivity/tree (kg)			Oil (%)		
	2012	2013	Average	2012	2013	Average
1	50.83	18.82	34.83 <sup>ab</sup>	12.72	14.88	13.80 <sup>bc</sup>
2	65.12	44.54	54.83 <sup>c</sup>	13.11	15.21	14.16 <sup>c</sup>

3	76.40	49.98	63.19 <sup>b</sup>	16.37	18.35	17.36 <sup>b</sup>
4	87.20	61.29	74.25 <sup>a</sup>	18.19	19.97	19.08 <sup>a</sup>
LSD (0.05)	6.792			1.83		

\* in the same column, the values share one letter, there is no significant difference between them

#### 3.4.1 Productivity per tree (kg)

We notice from Table (6), which shows the results of foliar spraying with the macro and microelements on the productivity per tree (kg), that all the spraying treatments (2, 3, and 4) outweighed the control by significant differences, as the second treatment (one foliar spraying before flowering) an increase of up to 20 kg above the control. Also, the increase in the number of spraying times led to an additional increase in productivity per tree, as the third treatment (two foliar sprayings: before flowering, and after flowering) achieved a significant increase in productivity per tree of 8.36 kg compared to the second treatment (one foliar spraying before flowering). As well, the fourth treatment (three foliar sprayings: before flowering, after flowering, and 15 days after the second) achieved a significant increase of 11.06 kg above the third treatment (two foliar sprayings: before flowering, and after flowering). Figure 11.

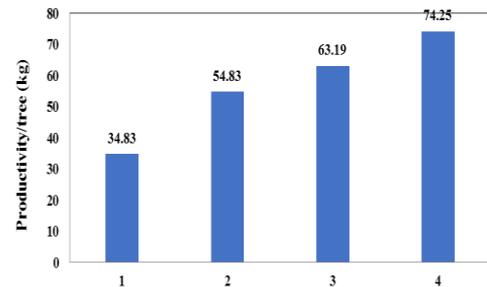


Figure 11: The effect of foliar spraying on the productivity of tree

These results demonstrate the positive effect of foliar spraying with macro and microelements in causing a significant increase in the yield per tree. Our results are consistent with many studies that have demonstrated the importance of foliar spraying in improving productivity in olive trees. Whereas, Tagliaviniet *al.*, (2002) and Ben-Rouinaet *al.* (2002) mentioned the positive response in olive productivity by increasing the availability of mineral nutrition. El-Khawaga (2007) and Abbasiet *al.* (2012) confirmed the increased productivity of olive trees when spraying with a mixture of macro and microelements. Ragab (2002) also reported an increase in productivity when spraying trees with macroelements. While, Pericaet *al.*, (2001) reported that spraying with microelements increased the productivity of olive trees. Cimato et al. (1990) mentioned that the foliar spraying of olive trees with a nitrogen component has a great role in the vegetative and fruiting growth of these trees, as production increases by increasing the fruit-set and preventing the fruits fall. Ben-Mimounet *al.*, (2008) found that potassium

spraying significantly increased productivity compared to control.

### 3.4.2 Percentage of oil (%)

It appears from Table (6), which shows the results of the foliar spraying with macro and microelements in the oil percentage, that the second treatment (one foliar spraying before flowering) did not achieve a significant increase than the control, while the increase in the number of foliar spraying times, resulted in a significant increase in the percentage of oil compared to the control, where the third treatment (two foliar sprayings: before and after the flowering) achieved an increase in the oil percentage that reached 3.56% than the control, and the fourth treatment (three foliar sprayings: before flowering, after flowering, and 15 days after the second) was achieved an increase in the oil content of 5.28% over the control, Figure (12).

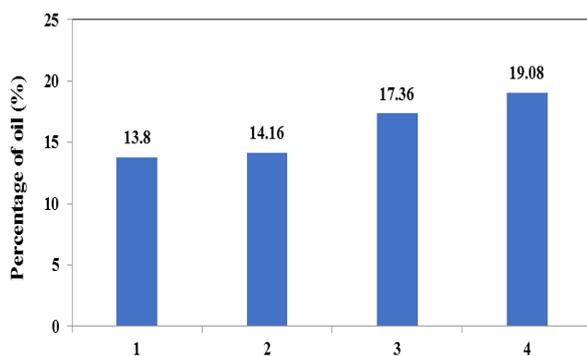


Figure 12: The effect of foliar spraying on the oil percentage

The above-mentioned results show the positive effect of foliar spraying with macro and microelements in causing a significant increase in the percentage of oil. The results obtained in our research are consistent with many previous studies. Whereas, El-Khawaga (2007) mentioned that foliar spraying with macro and microelements resulted in a significant increase in the fruit content of oil in Manzanillo variety olive. Whereas, the accumulation of oil in olive fruits is a process that depends on the amount of carbohydrates produced from the fruits and old leaves. Ben-Khelil and Mustapha (2013) also mentioned in his research on Arbequina olive variety (for oil production) that foliar fertilization has an effect on improving productivity and increasing oil content in treated fruits.

### 3.5 Comparing the two research years

By comparing the means of studied indicators between the two research years, we found the results displayed in Table (7).

TABLE 6

Comparing the means of studied indicators between the two research years

Trait	Season		LSD (0.05)
	2012	2013	
Annual vegetative growth of branch (cm)	12.53 <sup>b</sup>	17.97 <sup>a</sup>	0.491
Leaf surface (cm <sup>2</sup> )	6.02 <sup>b</sup>	6.84 <sup>a</sup>	0.215
Fruit-set (%)	6.42 <sup>b</sup>	7.03 <sup>a</sup>	0.147
Fruit weight (g)	3.15 <sup>b</sup>	4.39 <sup>a</sup>	0.124
Fruit size (mL)	2.29 <sup>b</sup>	3.00 <sup>a</sup>	0.129
Pulp/fruit ratio (%)	84.72 <sup>b</sup>	86.71 <sup>a</sup>	0.522
Percentage of oil (%)	17.27 <sup>b</sup>	19.24 <sup>a</sup>	0.47
Number of flowering clusters/branch	26.02 <sup>a</sup>	19.25 <sup>b</sup>	0.483
Number of flowers/flowering cluster	21.18 <sup>a</sup>	15.47 <sup>b</sup>	0.38
Number of flowers/branch	565.58 <sup>a</sup>	316.39 <sup>b</sup>	15.83
Number of fruits/branch	36.87 <sup>a</sup>	22.90 <sup>b</sup>	3.54
<b>Productivity/tree (kg)</b>	<b>80.86<sup>a</sup></b>	<b>54.04<sup>b</sup></b>	<b>3.037</b>

\* in the same line, the values share one letter, there is no significant difference between them

Table (7) shows the difference in the means of studied indicators between the years 2012 and 2013. Where the year 2012 exceeded the production indicators (number of flowering clusters/branch, number of flowers/flowering cluster, number of flowers/branch, number of fruits/branch and productivity/tree). While in 2013, it outperformed the indicators of vegetative growth (annual vegetative growth of branch, leaf surface, percentage of fruit-set) and fruit characteristics (fruit weight, fruit size, pulp/fruit ratio, percentage of oil). Thus, the first year of research was a high year of production, while the second year was a low year of production (the phenomenon of alternate bearing), and on the contrary, for vegetative growth. Our results are consistent with several studies that showed the difference in the rate of production and vegetative growth between the year of high production and the year of low production (Henar, 2002).

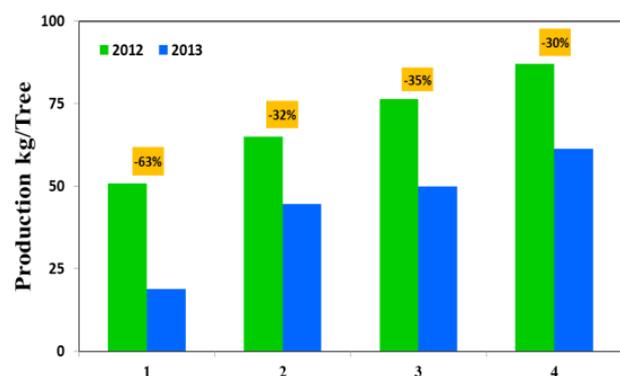


Figure 13: The difference in olive tree productivity in experimental treatments between the two study years

On the other hand, all treatments resulted in reducing the difference in the means of indicators studied between the two study years, compared to the control. This was evident in the tree productivity index. While the productivity of the control decreased in the second year of the research by 63% from the first year, the decrease in productivity ranged between 35% in

the third treatment (two sprays) and 30% in the fourth treatment (three sprays), Figure (13).

According to these results, the value of foliar spraying with macro and microelements is not only in increasing production in the same year of application, but also in reducing the phenomenon of alternate bearing and gaining a constant production over the years.

#### IV. CONCLUSION

Foliar spraying with macro and microelements gave a significant increase compared to the control, in most of the studied indicators (the leaf surface, the number of flowering clusters/branch, the number of flowers/flowering cluster, the number of flowers/branch, the percentage of fruit-set, the number of fruits/branch, the fruit weight, the fruit size, and the pulp/fruit ratio).

The increase in the number of foliar spraying showed a significant increase in the indicators of vegetative growth, tree productivity and percentage of oil.

There was a clear difference in the productivity between the two years of the study (alternate bearing), but all the applied treatments reduced this difference compared to the control (limiting the alternate bearing).

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**Citation of this Article:**

Dr. Rida DRAIE, Dr. Waseem ALHAJ-RABIE, Asmaa AL-MAHMOUD, “Influence of Foliar Spraying with Macro and Microelements on the Growth and Productivity of Olive Trees in Idleb Province” Published in *International Research Journal of Innovations in Engineering and Technology - IRJIET*, Volume 4, Issue 4, pp 12-24, April 2020. <https://doi.org/10.47001/IRJIET/2020.404003>

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