# Effect of Humic and Salicylic Acids Foliar Application on Vegetative Growth and Fruit Quality of Olive (c.v Sorani and Khadrawi)

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## Abstract

This study was carried out on 15 years old trees of two Syrian olives (*Olea europaea* L.) cultivars Sorani and Khadrawi during 2020-2021 growing season at research orchard, of Horticulture department / College of Agricultural Engineering sciences, University of Sulaimani, Iraqi Kurdistan region. Humic and salicylic acids foliar application with three levels (0, 2000 and 4000 ppm) and (0, 750 and 1500 ppm) were applied respectively (before and after full bloom as well as at fruit set). The parameters annual shoot length, fruit set percentage, fruit weight, fruit volume, oil content in fruit and leaf (nitrogen, phosphorus and potassium) content were studied, and the results showed that cultivar had significant effects on all studied parameters except (fruit weight and fruit volume). Maximum concentration of humic acid (4000ppm) recorded maximum values in all parameters compared to the other concentrations, and also had significant effects on all parameters. Except (fruit volume) all parameters be affected significantly by salicylic acid application.

**Keywords:** *Olea europaea*, cultivar, Humic acid, salicylic acid and olive quality.

## Introduction

Olive (*Olea europaea* L.) belongs to Oleaceae family which is native to the Mediterranean region, well adapted to drought, hot summer and poor soil (34). Olives are known as the oldest cultivated trees in the world (25). Olive cultivation plays an important role in agricultural economy of some countries. More than eight million hectares of olive trees are cultivated worldwide among which the Mediterranean basin presents around 98 %. The top ten countries of olive production are Spain, Italy, Turkey, Greece, Morocco, Egypt, Algeria, Portugal, Tunisia and Syria (18). In Iraq, olive groves are concentrated in Bashiqa area of Ninawa province and the number of olive orchards in Kurdistan region is about 3000 which produced more than 4000 tons of which 527 tons of oil were produced in addition to the part used in the table. Olive is an important food for human being because of their high nutritional values. Olive fruits are used for both oil and pickles purposes.

Humic acids are complex long chain molecules produced naturally from organic matter decomposition in soils, oceans and streams (21). Humic substances chemically consist of humic acid, fulvic acid and humin (11and 38) Displayed evidence that humic substances induced plant growth and thus increased yield through their effects on some plant mechanisms such as: photosynthesis, protein synthesis, cell respiration, enzyme activities, nutrient and water uptake.

Salicylic acid is a phenolic compound produced naturally and endogenously by plants which have various effects on biochemical and physiological functions in plants (9 and 27). Salicylic acid is a substantial plant hormone that plays biological roles in regulating plant growth and development, also, it can function as modulators for plant immune signaling network responses. Ability of plants to develop gained immunity after pathogen infection was first submitted in 1933 (30). Salicylic acid acts as a key role of disease resistant and thermogenesis (2). It also induced important physiological processes in plants such as proline metabolism, nitrogen metabolism, antioxidant defense system, photosynthesis and plant water relations, with resistance and tolerance to many abiotic stresses (28). Salicylic acid effects on olive trees mostly focused on the growth responses to drought and modulation of its physiology (12).

The study was aimed to investigate the impact of humic acid and salicylic acid on quantitative and qualitative fruit properties and the leaf nutrients content of Sorani and Khadrawi olive cultivars.

## Material and Methods

This study was achieved during 2020-2021 growing season at the orchard of the department of Horticulture, College of Agricultural Engineering sciences, Sulaimani University. The area of experiment is considered as semi-arid region which is cold in winter hot and dry in summer (29).

Two fifteen-year Syrian olive cultivars (Sorani and Khadrawi) trees have been used which were planted 4×4 m a part, the orchard was being irrigated by surface irrigation system. Twenty-seven trees for each cultivar were selected on the basis of size, uniformity, healthy state and vigor.

Foliar application of humic acid and salicylic acid was conducted three times. First was on April 17, 2021 before blooming, second was on may17, 2021 after full bloom and third on July 27, 2021 after fruit setting (4 and 25)

The following parameters were recorded:

1. Annual shoot length (cm):

During final of growth season on November 15, 2021, eight shoot length were measured and the average length was calculated.

2. Fruit set percentage (%):

Flower buds were counted in 8 branches for each tree, the fruit set percentage was calculated.

3. Fruit weight (gm):

The weight of twenty fruits was recorded by sensitive balance and the average obtained.

4. Fruit volume (cm3):

Fruits size was measured by using water displacement method. Ten olive fruits were put into a cylinder containing water till marked point then recorded the water level rises.

5. Oil content (%):

Oil percentage was determined in the fruit flesh on dry weight basis using the Soxhlet oil extraction apparatus with hexane (60-80°) boiling point according to Li *et al.* (16), Hagagg *et al*. (20) and EL-Zakhem (31).

6. Leaf nitrogen, phosphorus and potassium (%):

On November 15, 100 leaves were collected from each treatment, the samples were dried and stored in dark and dry place, after that the dried leaves were grinded with in a stainless-steel coffee mill to determine N, P and K component. Nitrogen content (%) determined with Micro kjeldahl method. Phosphorus content determined with colorimetric methods. Potassium content determined with flame photometer method by May and Seed (35).

Factorial Randomized Complete Block Design (RCBD) was used. Three factors (two cultivars + three humic acid and salicylic acid concentrations) were used with three replicates. Comparisons among the means were achieved by using the least significant difference (L.S.D.) test at ($P \leq 0.05$) (7). Data were analyzed by statistical software XLSTAT (Version 2016.02.28451).

## Results and Discussion

1. Annual shoot length (cm):

Table (1) presents the effect of olive cultivars, humic acid, salicylic acid and their interactions on annual shoot length. Significant differences were recorded between cultivars, Sorani cultivar recorded maximum value (18.882 cm) significantly superior to Khadrawi (17.193 cm), which may be due to genetic variations between them (6). On the other hand, applied humic acid significantly affected on annual shoot length, 4000 ppm gave 19.992 cm shoot length which is superior to both 2000 ppm and the control, which may be due to the effect of humic acid on the function of cell membranes that may promote uptake nutrient and thus plant growth by expressible hormone like substances (38). Salicylic acid effects significantly as 1500 ppm, salicylic acid was superior significantly to the control, variation among treatments can be as a result of the role of salicylic acid as a growth promoter (6). Significant differences recorded in the interaction between cultivars and humic acid, maximum value (20.996 cm) recorded when maximum concentration of humic acid (4000 ppm) sprayed on Sorani cultivar. data show that there are significant differences noted in the interaction between cultivar and salicylic acid the highest value recorded in an interaction between Sorani cultivar and (1500 ppm) of salicylic acid the value is (20.290 cm), lowest value (16.111 cm) recorded when no salicylic acid was sprayed on Khadrawi cultivar, these variations can be obtained because cultivars and salicylic acid concentrations individually have significant effects on annual shoot length. Moreover, in interaction between humic acid and salicylic acid applications significant differences are documented the value (22.261 cm) which recorded when both maximum value of humic and salicylic acid are sprayed and the control gave lowest

value (15.294 cm), our previous results showed that maximum concentrations of humic acid and salicylic acid individually obtained maximum value of annual shoot length and the lowest value observed in control. Interactions among cultivars, humic acid and salicylic acid record maximum value of olive annual shoot length (23.378 cm) observed in interactions among Sorani cultivar and maximum concentrations of both humic acid (4000 ppm) and salicylic acid (1500 ppm).

**Table 1.** Effect of olive cultivars, humic acid, salicylic acid and their interactions on the annual shoot length (cm)

| Cultivars | Humic Acid (ppm) | Salicylic Acid (ppm) 0 | 750 | 1500 | Cultivar x Humic Acid | Mean Effect of Cultivars |
|---|---|---|---|---|---|---|
| Sorani | 0 | 16.022 bc | 17.133 bc | 17.256 bc | 16.804 bc | 18.822 a |
| | 2000 | 17.567 bc | 18.411 abc | 20.022 abc | 18.667 ab | |
| | 4000 | 18.744 abc | 20.867 ab | 23.378 a | 20.996 a | |
| Khadrawi | 0 | 14.567 c | 15.800 bc | 15.856 bc | 15.407 c | 17.193 b |
| | 2000 | 16.500 bc | 17.356 bc | 18.111 bc | 17.322 bc | |
| | 4000 | 17.267 bc | 18.133 bc | 21.144 ab | 18.848 ab | |
| Mean Effect of Salicylic Acid | | 16.778 b | 17.950 ab | 19.294 a | | |
| Cultivar x Salicylic Acid | Sorani | 17.444 ab | 18.804 ab | 20.290 a | Mean Effect of Humic Acid | |
| | Khadrawi | 16.111 b | 17.096 b | 18.370 ab | | |
| Humic Acid x Salicylic Acid | 0 | 15.294 c | 16.467 bc | 16.556 bc | 16.106 c | |
| | 2000 | 17.033 bc | 17.883 bc | 19.067 ab | 17.994 b | |
| | 4000 | 18.006 bc | 19.500 ab | 22.261 a | 19.922 a | |

Means of each factor and their interactions followed with the same letters are not significantly different from each other's according to Duncan's multiple ranges test at 5% level.

2. Fruit set percentage (%):

Data in table (2) show the effect of cultivar, humic acid, salicylic acid and their interactions on fruit set percentage. Significant differences record between cultivars, Sorani cultivar recorded (0.720 %) and Khadrawi cultivar gave (0.652 %). This difference may be due to that mentioned by (10) that fruit set depends on cultivar. On the other hand, Sorani cultivar recorded maximum value of nitrogen and phosphorus (17) who mentioned that low concentration of nitrogen and phosphorus caused lower olive flower parentage. Moreover, the adaptability of cultivars to the climate is one of an important factor effect on fruit set (23). Humic acid effected olive fruit set significantly, maximum value (0.732 %) record in (4000 ppm) humic acid, minimum value (0.621 %) record in control, these variabilities may be due to the effect of humic acid on the contents of numerous elements and the availability of many minerals required to flower set (17). Salicylic acid recorded significant effect on olive fruit set percentage, maximum value (0.716 %) recorded in (1500 ppm) and the control gave minimum value (0.643 %). The effect of salicylic acid on fruit set may be due to the increase of total chlorophyll content as a result of salicylic acid application which caused more carbohydrates production in photosynthesis process and hence more vegetative growth which lead to the increase of fruit set (3). On the other hand, salicylic acid is beneficial for the increase of flowering percentage as it works like endogenous growth regulator (14). Significant differences observed in the interaction between cultivar and humic acid, upmost value (0.783 %) recorded in Sorani cultivar applied with 4000 ppm humic acid, which is superior significantly to most other combinations. Data showed significant

differences in combination between cultivar and salicylic acid on fruit set, highest value (0.764 %) recorded in interaction between (Sorani cultivar with1500 ppm salicylic acid) while the lowest value (0.616 %) recorded in Khadrawi combined with the control. Humic acid and salicylic acid combinations also affected significantly on fruit set, maximum concentrations of both acids gave highest value (0.747 %) fruit set while control of both acids gave the lowest value (0.545 %). In interactions among the three factors (cultivar, humic acid and salicylic acid) interactions among (Sorani cultivar, 4000 ppm humic acid and 750 ppm salicylic acid) gave maximum value (0.800 %) and minimum value (0.534 %) recorded in (Khadrawi cultivar untreated with both acids).

**Table 2.** Effect of olive cultivars, humic acid, salicylic acid and their interactions on the olive fruit set percentage

| Cultivars | Humic Acid (ppm) | Salicylic Acid (ppm) 0 | 750 | 1500 | Cultivar x Humic Acid | Mean Effect of Cultivars |
|---|---|---|---|---|---|---|
| Sorani | 0 | 0.556 cd | 0.630 bcd | 0.732 ab | 0.639 cd | 0.720 a |
| | 2000 | 0.706 ab | 0.750 ab | 0.760 ab | 0.738 ab | |
| | 4000 | 0.749 ab | 0.800 a | 0.799 a | 0.783 a | |
| Khadrawi | 0 | 0.534 d | 0.634 bcd | 0.642 bcd | 0.604 d | 0.652 b |
| | 2000 | 0.652 a-d | 0.692 abc | 0.668 a-d | 0.671 bc | |
| | 4000 | 0.662 a-d | 0.689 abc | 0.696 abc | 0.682 bcd | |
| Mean Effect of Salicylic Acid | | 0.643 b | 0.699 a | 0.716 a | | |
| Cultivar x Salicylic Acid | Sorani | 0.670 bc | 0.726 ab | 0.764 a | Mean Effect of Humic Acid | |
| | Khadrawi | 0.616 c | 0.672 bc | 0.669 bc | | |
| Humic Acid x Salicylic Acid | 0 | 0.545 c | 0.632 bc | 0.687 ab | 0.621 b | |
| | 2000 | 0.679 ab | 0.721 ab | 0.714 ab | 0.705 a | |
| | 4000 | 0.706 ab | 0.744 a | 0.747 a | 0.732 a | |

Means of each factor and their interactions followed with the same letters are not significantly different from each other's according to Duncan's multiple ranges test at 5% level.

**3.** Fruit weight (gm)**:**

The data in table (3) demonstrated the effect of olive cultivar, spray with humic acid, salicylic acid and their interactions on fruit weight. No significant effect recorded between two cultivars. 4000 ppm humic acid dominated significantly the after two levels (2.129 gm vs. 1.970 and 1.407 gm), the increase fruit weight by humic acid may be due to the decrease effect of element deficiency with humic acid application also, and this acid raises the cell permeability that caused more water and nutrient uptake (8). On the other hand, our results showed that use of humic acid increased the contents of (nitrogen, phosphorus and potassium) in olive leaves and thus enhancing plant growth. Salicylic acid spray recorded significant differences compared to control but no significant differences observed between (750 and 1500 ppm), maximum value (2.013 gm) obtained in (1500 ppm salicylic acid) and control recorded the lowest (1.595 gm). Salicylic acid caused the increase of total chlorophyll content and thus more carbohydrate production from photosynthesis and more vegetative growth and fruit yield would be obtained (2 and 3). Interaction between cultivar and humic acid significantly increased olive fruit weight, interaction of (Khadrawi cultivar and 4000 ppm of humic acid) gave maximum value (2.204 gm) which is superior to most other combinations, Sorani cultivar combined with control recorded minimum value (1.366 gm), differences among the combinations may be as a result of

significant effect of both humic acid and cultivar individually on fruit weight. In interaction between cultivar with salicylic acid significant differences were obtained, interaction Khadrawi cultivar with (1500 ppm) salicylic acid recorded maximum value (2.068 gm) which dominated significantly some other combinations. Salicylic acid individually affected significantly on fruit weight which also appeared in the interactions. Significant differences on olive fruit weight recorded in combination between both acids (humic and salicylic), highest concentration of both acids gave maximum value (2.368 gm) and the control obtained minimum (1.355 gm). These differences may due to the individual effects of both factors. With regard to three factors combinations (cultivar, humic and salicylic acid) on their effect on fruit weight, Khadrawi combinate with 4000 ppm humic acid and 1500 ppm salicylic acid recorded maximum value (2.411 gm) which is superior to most other combinations and Sorani cultivar intricate with the control gave the lowest value (1.319 gm).

**Table 3.** Effect of olive cultivars, humic acid, salicylic acid and their interactions on the fruit weight (gm)

| Cultivars | Humic Acid (ppm) | Salicylic Acid (ppm) 0 | 750 | 1500 | Cultivar x Humic Acid | Mean Effect of Cultivar |
|---|---|---|---|---|---|---|
| | 0 | 1.319 g | 1.391 fg | 1.389 fg | 1.366 c | |
| Sorani | 2000 | 1.709 def | 2.076 abc | 2.159 ab | 1.981 b | 1.801 a |
| | 4000 | 1.805 cde | 2.033 bcd | 2.325 ab | 2.055 ab | |
| | 0 | 1.390 fg | 1.469 efg | 1.486 efg | 1.448 c | |
| Khadrawi | 2000 | 1.553 efg | 2.020 bcd | 2.306 ab | 1.959 b | 1.871 a |
| | 4000 | 1.795 cde | 2.407 a | 2.411 a | 2.204 a | |
| Mean Effect of Salicylic Acid | | 1.595 b | 1.899 a | 2.103 a | | |
| Cultivar x Salicylic Acid | Sorani | 1.611 c | 1.833 b | 1.958 ab | Mean Effect of Humic Acid | |
| | Khadrawi | 1.580 c | 1.965 ab | 2.068 a | | |
| Humic Acid x Salicylic Acid | 0 | 1.355 e | 1.430 de | 1.437 de | 1.407 c | |
| | 2000 | 1.631 cd | 2.048 b | 2.232 ab | 1.970 b | |
| | 4000 | 1.800 c | 2.220 ab | 2.368 a | 2.129 a | |

Means of each factor and their interactions followed with the same letters are not significantly different from each other's according to Duncan's multiple ranges test at 5% level.

**4.** Fruit volume ($cm^3$):

Table (4) shows no significant effect of the two cultivars on fruit volume, the values (2.002 and 1.910 $cm^3$) for (Sorani and Khadrawi) respectively. Humic acid gave significant effect on fruit volume the highest concentration (4000 ppm) recorded maximum value (2.097 $cm^3$), while control gave the minimum (1.843 $cm^3$), these differences may be due to the hormone-like activity of humic acid through its involvement in photosynthesis, protein synthesis and various enzymatic reaction (36). Moreover, salicylic acid recorded no significant effect on fruit volume (1.846, 1.964 and 2.056 $cm^3$) for (0, 750 and 1500 ppm) respectively. Interaction between cultivar and humic acid gave significant differences, the upmost value (2.132 $cm^3$) recorded in interaction between Khadrawi cultivar with (4000 ppm) humic acid, lowest value (1.752 $cm^3$) recorded for same cultivar with the control, these significant differences may be due to humic acid effect on the volume as no significant effects recorded between the two cultivars. No significant differences effect achieved in

interaction between cultivar and salicylic acid, Sorani cultivar combined with 1500 ppm salicylic acid gave maximum value (2.097 $cm^3$), and non-treated Khadrawi cultivar with salicylic acid recorded the lowest (1.801 $cm^3$). The combination among (cultivar, humic acid and salicylic acid) recorded no significant differences maximum value (2.212 $cm^3$) recorded for (Khadrawi cultivar combined with 4000 ppm humic acid and 750 salicylic acid).

**Table 4.** Effect of cultivars, humic acid, salicylic acid and their interactions on fruit volume ($cm^3$)

| Cultivars | Humic Acid (ppm) | Salicylic Acid (ppm) 0 | 750 | 1500 | Cultivar x Humic Acid | Mean Effect of Cultivars |
|---|---|---|---|---|---|---|
| Sorani | 0 | 1.837 a | 1.954 a | 2.010 a | 1.934 ab | 2.002 a |
| | 2000 | 1.947 a | 1.983 a | 2.099 a | 2.010 ab | |
| | 4000 | 1.891 a | 2.111 a | 2.183 a | 2.062 ab | |
| Khadrawi | 0 | 1.730 a | 1.698 a | 1.828 a | 1.752 b | 1.910 a |
| | 2000 | 1.688 a | 1.826 a | 2.019 a | 1.845 ab | |
| | 4000 | 1.985 a | 2.212 a | 2.199 a | 2.132 a | |
| Mean Effect of Salicylic Acid | | 1.846 a | 1.964 a | 2.056 a | | |
| Cultivar x Salicylic Acid | Sorani | 1.892 a | 2.016 a | 2.097 a | Mean Effect of Humic Acid | |
| | Khadrawi | 1.801 a | 1.912 a | 2.016 a | | |
| Humic Acid x Salicylic Acid | 0 | 1.784 a | 1.826 a | 1.919 a | 1.843 b | |
| | 2000 | 1.818 a | 1.904 a | 2.059 a | 1.927 ab | |
| | 4000 | 1.938 a | 2.162 a | 2.191 a | 2.097 a | |

Means of each factor and their interactions followed with the same letters are not significantly different from each other's according to Duncan's multiple ranges test at 5% level.

5. Oil content (%):

Table (5) illustrates that cultivars significantly affected on oil percentage of olive fruit, Sorani cultivar recorded maximum value (30.243 %) which is superior to Khadrawi (25.438 %). These results may be due to the effect of cultivar as a major factor for the variability in fruit oil content (19 and 15). Humic acid recorded significant effect on fruit oil percentage, maximum value (30.680 %) was recorded for (4000 ppm) humic acid which dominated significantly the other two levels of humic acid. These results agree with these mentioned by (33) that humic acid improves vegetative growth in addition to enhancing photosynthesis, respiration and the increase of enzyme synthesis all these factors have positive effect on oil accumulation in fruit. Significant differences documented among the values of mean effect of salicylic acid, highest value (30.199 %) recorded for (1500 ppm) salicylic acid which is superior to both control and 750 ppm salicylic acid. Abd-El-Rhman and Attia (3) mentioned that salicylic acid works as hormone like substance that regulates plant growth and development which may cause the increase in fruit oil content. Interactions between cultivars and humic acid significantly raised the fruit oil percentage, Sorani cultivar when interacted with (4000 ppm) gave maximum value (33.770 %) which is superior to the other combinations. In combination between cultivar and salicylic acid the value (32.733 %) dominated significantly the other combinations. Also, interactions of humic acid and salicylic acid gave significant differences value in fruit oil percentage, control (interaction between 0 ppm of both acid) gave the lowest value (22.084 %), and increased to (33.113 %) in the interaction between (4000 ppm of humic acid with 1500 ppm salicylic acid)

which is superior to the other combinations. Interactions of cultivar, humic acid and salicylic acid affected significantly on olive fruit oil percentage, Sorani cultivar with combined with (4000 ppm) humic acid and (1500 ppm) salicylic acid gave the highest value (36.146 %) which dominated all the other combinations.

**Table 5.** Effect of cultivars, humic acid, salicylic acid and their interactions on oil percentage in dry weight (%).

| Cultivars | Humic Acid (ppm) | Salicylic Acid (ppm) 0 | 750 | 1500 | Cultivar x Humic Acid | Mean Effect of Cultivars |
|---|---|---|---|---|---|---|
| Sorani | 0 | 23.046 m | 27.161 i | 29.044 f | 26.417 d | 30.243 a |
| | 2000 | 28.359 g | 30.259 e | 33.008 c | 30.542 b | |
| | 4000 | 31.036 d | 34.129 b | 36.146 a | 33.770 a | |
| Khadrawi | 0 | 21.122 n | 23.032 m | 25.047 k | 23.067 f | 25.438 b |
| | 2000 | 23.642 l | 25.461 j | 27.870 h | 25.658 e | |
| | 4000 | 25.297 jk | 27.391 i | 30.080 e | 27.589 c | |
| Mean Effect of Salicylic Acid | | 25.417 c | 27.906 b | 30.199 a | | |
| Cultivar x Salicylic Acid | Sorani | 27.480 c | 30.516 b | 32.733 a | Mean Effect of Humic Acid | |
| | Khadrawi | 23.354 e | 25.295 d | 27.666 c | | |
| Humic Acid x Salicylic Acid | 0 | 22.084 i | 25.067 h | 27.046 f | 24.742 c | |
| | 2000 | 26.001 g | 27.860e | 30.439 c | 28.100 b | |
| | 4000 | 28.166 d | 30.760 b | 33.113 a | 30.680 a | |

Means of each factor and their interactions followed with the same letters are not significantly different from each other's according to Duncan's multiple ranges test at 5% level.

6. Leaf nitrogen content (%):

Data in table (6) indicate that the cultivar, humic acid, salicylic acid and their interactions exhibited significant differences on leaf nitrogen content. The highest increase in cultivars effect was obtained with Sorani cultivar which was (1.475 %) and lowest (1.377 %) recorded for the other cultivar, these results may be due to the minerals content in olive leaves of different cultivars, indicating differential capability of cultivar to take minerals from the soil (37). With reference to humic acid effects, (0 ppm) control gave the lowest value (1.326 %) and increased to (1.445 %) in (2000 ppm) and arrived to (1.507 %) in (4000 ppm) which is superior to the other two concentrations, these outcomes may be to that reported by Maibodi *et al*.(32) who mentioned that ion uptake activated by treatments with humic acid effects on membrane permeability. Leaves nitrogen content affected significantly by spray salicylic acid, maximum concentration of salicylic acid recorded highest value (1.486 %), and minimum value (1.377 %) record in the control. These differences may be due to the role of salicylic acid to encourage growth improve plant physiological activity and motivate plant to absorb more nutrients (22). In interaction between cultivar and humic acid, Sorani combined with 4000 ppm humic acid gave the highest value (1.529%) nitrogen content which excessed significantly the other combinations and minimum value (1.247 %) recorded for the interaction between (Khadrawi and 0 ppm humic acid) .The results may be due to the effect of both individual factors on leaves nitrogen content. In combination between cultivar and salicylic acid, the highest value (1.536 %) obtained in the interaction between (Sorani cultivar and highest value of salicylic acid) that superior to the other combinations and Khadrawi cultivar when non-treated with salicylic acid obtained minimum value (1.331 %), This effect may be due to the influence of individual effect

of both factors. With reference to the combinations between humic acid and salicylic acid the maximum value of nitrogen content in olive (1.594%) was obtained from 4000 ppm humic acid entreated with 1500 ppm salicylic acid which is superior to all other combinations while combined control of both acids resulted in minimum value (1.257 %), These results may be due to the effect of both factors individually. Also, combinations among the three factors have significant effect on nitrogen content of olive tree, the highest value (1.680 %) recorded in interactions among (Sorani cultivar * 4000 ppm humic acid * 1500 ppm salicylic acid) which dominated significantly the other combinations, interactions among (Khadrawi cultivar * zero of both acid) recorded the lowest value (1.117 %).

**Table 6.** Effect of olive cultivars, humic acid, salicylic acid and their interactions on the leaf nitrogen content (%)

| Cultivars | Humic Acid (ppm) | Salicylic Acid (ppm) 0 | 750 | 1500 | Cultivar x Humic Acid | Mean Effect of Cultivars |
|---|---|---|---|---|---|---|
| | 0 | 1.398 c | 1.408 c | 1.410 c | 1.405 c | |
| Sorani | 2000 | 1.469 b | 1.481 b | 1.519 b | 1.490 b | 1.475 a |
| | 4000 | 1.400 c | 1.508 b | 1.680 a | 1.529 a | |
| | 0 | 1.117 e | 1.223 d | 1.400 c | 1.247 d | |
| Khadrawi | 2000 | 1.404 c | 1.396 c | 1.401 c | 1.400 c | 1.377 b |
| | 4000 | 1.472 b | 1.474 b | 1.508 b | 1.485 b | |
| Mean Effect of Salicylic Acid | | 1.377 c | 1.415 b | 1.486 a | | |
| Cultivar x Salicylic Acid | Sorani | 1.422 c | 1.466 b | 1.536 a | Mean Effect of Humic Acid | |
| | Khadrawi | 1.331 e | 1.364 d | 1.436 c | | |
| Humic Acid x Salicylic Acid | 0 | 1.257 f | 1.316 e | 1.405 cd | 1.326 c | |
| | 2000 | 1.437 cd | 1.438 cd | 1.260 bc | 1.445 b | |
| | 4000 | 1.459 cd | 1.491 b | 1.594 a | 1.507 a | |

Means of each factor and their interactions followed with the same letters are not significantly different from each other's according to Duncan's multiple ranges test at 5% level

**7. Leaf phosphorus content (%):**

Table (7) illustrates that cultivars affected significantly on leaf phosphorus content, Sorani was superior significantly to Khadrawi (0.134 and 0.128 %) respectively, these differences may be due to the differences in genotype characteristics which might influence particular nutrient uptake efficiency (13 and 24). Spraying olive trees with humic acid at 4000 ppm produced significant differences compared to 2000 ppm and the control the highest percentages (0.147 %) recorded for (4000 ppm) of humic acid and the lowest (0.117 %) recorded for control. These results may be due to positive effect of humic acid on plant growth through its effect on mechanisms such as photosynthesis, respiration, protein synthesis, water and nutrient uptake and enzyme activities (40, 26 and 35). Moreover, leaves phosphorus content increases significantly when spraying trees with 750 ppm salicylic acid gave maximum value (0.138 %) which dominated significantly both 1500 ppm salicylic acid and the control, the differences may be due to that mentioned by (39) which documented that salicylic acid improves nutrient uptake by modifying the activities of various enzymes, and conserves the solidity of cell membranes. In interaction between cultivars and humic acid, it was noticed that Khadrawi interacted with 4000 ppm humic acid obtained (0.150 %) phosphorus content which is superior

significantly to the other combinations. These results can be due to the effect of both individual factors. With regard to combination between cultivars and salicylic acid, Khadrawi cultivar with (750 ppm) recorded maximum value (0.143 %) which dominated significantly the other combinations and the control combinations with the Khadrawi gave the lowest which may be due to the effect of salicylic acid individually. Also, both acid (humic and salicylic) interactions gave significant differences, maximum value (0.162 %) recorded in combination between (humic acid 4000 ppm and salicylic acid 750 ppm), while untreated trees (control) for both acids recorded minimum value (0.109 %) of leaves phosphorus content. The combination among (cultivar * humic acid * salicylic acid) gave significant differences in leaf phosphorus content, highest value (0.170 %) obtained in interactions of (Khadrawi cultivar, 4000 ppm of humic acid and 750 ppm of salicylic acid) which was superior significantly to the other combinations and Sorani cultivar when untreated with two acids record lowest value (0.099 %).

**Table 7.** Effect of olive cultivars, humic acid, salicylic acid and their interactions on leaf phosphorus content (%)

| Cultivars | Humic Acid (ppm) | Salicylic Acid (ppm) 0 | 750 | 1500 | Cultivar x Humic Acid | Mean Effect of Cultivars |
|---|---|---|---|---|---|---|
| Sorani | 0 | 0.099 i | 0.116 h | 0.118 gh | 0.111 e | 0.134 a |
| | 2000 | 0.125 f | 0.130 e | 0.128 ef | 0.128 c | |
| | 4000 | 0.137 d | 0.153 b | 0.142 c | 0.144 b | |
| Khadrawi | 0 | 0.120 g | 0.130 e | 0.122 g | 0.124 d | 0.128 b |
| | 2000 | 0.131 e | 0.130 e | 0.120 g | 0.127 c | |
| | 4000 | 0.130 e | 0.170 a | 0.151 b | 0.150 a | |
| Mean Effect of Salicylic Acid | | 0.124 c | 0.138 a | 0.130 b | | |
| Cultivar x Salicylic Acid | Sorani | 0.127 d | 0.133 b | 0.129 c | Mean Effect of Humic Acid | |
| | Khadrawi | 0.120 e | 0.143 a | 0.131 c | | |
| Humic Acid x Salicylic Acid | 0 | 0.109 g | 0.123 e | 0.120 f | 0.117 c | |
| | 2000 | 0.128 d | 0.130 d | 0.124 e | 0.127 b | |
| | 4000 | 0.134 c | 0.162 a | 0.146 b | 0.147 a | |

Means of each factor and their interactions followed with the same letters are not significantly different from each other's according to Duncan's multiple ranges test at 5% level

**8.** Leaf potassium content (%)**:**

Table (8) illustrates the effect of olive cultivar, application with humic acid and salicylic acid and their interactions on leaf potassium content. In effect of cultivars significant differences recorded, Khadrawi cultivar recorded maximum value (1.014 %) which dominated significantly Sorani cultivar gave minimum value (0.997 %), the variations in potassium percentage in olive leaves may be due to that stated by Saykhul *et al*. (41) who showed that cultivars of olive have differences in root structure like the number of hairs, root elongations and distribution in the soil that caused variation in ability to absorb potassium. Moreover, the genetic of the plant may have vigor effect especially on nutrient uptake (41). Also spray olive tree with humic acid recorded significant differences in leaves potassium content, the concentrations (0, 2000 and 4000 ppm) recorded (0.884, 0.994 and 1.138 %) respectively, 4000 ppm humic acid was superior significantly to the other two levels. Humic acid improves nutrient uptake may be due to the increase in the cation exchange capacity (1). On the other hand (5) described that humic acid application raises cells membrane

permeability which caused the increase in nutrient uptake. When salicylic acid was sprayed on olive tree significant differences were observed in leaf potassium content, the values (0.959, 1.023 and 1.035 %) were observed for (0, 750 and 1500 ppm) respectively, and (1500 ppm) was superior significantly to the other two levels. The significant raise in leaf nutrient content sprayed with salicylic acid resulted from the function of this acid in resistance water stress in roots zone and facilitating this nutrient availability for absorption by plant roots and plant leaves (5). In interaction between olive cultivar and humic acid foliar application significant differences were observed for both upmost and lowermost values (1.187 and 0.881 %) successfully Khadrawi cultivar with highest acid concentration (4000 ppm) resulted significantly the highest value. The table clearly shows that interaction between cultivars and salicylic acid cause significant differences, maximum value (1.074 %) was recorded for (Khadrawi cultivar * 750 ppm salicylic acid), same cultivar with (0 ppm) salicylic acid gave minimum value (0.917 %). Spray humic acid with salicylic acid significantly increased potassium percentage in olive leave, peak value (1.202 %) recorded in the interaction between (4000 ppm humic acid and 750 ppm salicylic acid) which dominated significantly the other combinations, and least value (0.851 %) obtained in untreated tree (control) for both acids. Finally, the interaction among the three factors (cultivar vs humic acid vs salicylic acid) gave significant differences among in potassium percentage in olive leaves, interactions among (Khadrawi * 4000 ppm humic acid * 750 ppm salicylic acid) gave maximum value (1.401 %) which dominated significantly the other combinations, and minimum value (0.840 %) recorded in the interactions among (Khadrawi cultivar * 0 ppm of each acid).

**Table 8.** Effect of olive cultivars, humic acid, salicylic acid and their interactions on the leaf potassium content (%)

| Cultivars | Humic Acid (ppm) | Salicylic Acid (ppm) 0 | 750 | 1500 | Cultivar x Humic Acid | Mean Effect of Cultivars |
|---|---|---|---|---|---|---|
| Sorani | 0 | 0.862 f | 0.891 e | 0.911 e | 0.888 e | 0.997 b |
| | 2000 | 1.020 d | 1.021 d | 1.002 d | 1.014 c | |
| | 4000 | 1.121 c | 1.002 d | 1.143 b | 1.089 b | |
| Khadrawi | 0 | 0.840 g | 0.911 e | 0.891 e | 0.881 e | 1.014 a |
| | 2000 | 0.890 e | 0.910 e | 1.122 c | 0.974 d | |
| | 4000 | 1.021 d | 1.401 a | 1.140 bc | 1.187 a | |
| Mean Effect of Salicylic Acid | | 0.959 c | 1.023 b | 1.035 a | | |
| Cultivar x Salicylic Acid | Sorani | 1.001 d | 0.971 e | 1.019 c | Mean Effect of Humic Acid | |
| | Khadrawi | 0.917 f | 1.074 a | 1.051 b | | |
| Humic Acid x Salicylic Acid | 0 | 0.851 f | 0.901 e | 0.901 e | 0.884 c | |
| | 2000 | 0.955 d | 0.965 d | 1.062 c | 0.994 b | |
| | 4000 | 1.071 c | 1.202 a | 1.142 b | 1.138 a | |

Means of each factor and their interactions followed with the same letters are not significantly different from each other's according to Duncan's multiple ranges test at 5% level

## Conclusions:

From our results, we conclude that select suitable cultivars can product olive fruits that have proper qualities, this method is adequate and have several advantages. On another hand humic acid has an effect on all parameters that studied in this research, humic acid caused enhance the quality of olive and we suggest in future use other concentrations to select the preferable concentration. Also, salicylic acid has

significant effect to improve some quality olive property.

## Conflict of interest

The authors have no conflict of interest.

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