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# Effects of Supplementary Irrigation Plus Humic Acid Application on Olive Production

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***Authors' contributions***

*This work was carried out in collaboration between both authors. Author MR wrote the protocol, managed the literature searches, performed the statistical analysis and wrote the first draft of the manuscript. Author FJ designed the study, managed the analyses of the study. Authors MR and FJ read and approved the final manuscript. Both authors read and approved the final manuscript.*

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## ABSTRACT

A field study was conducted to investigate the effects of supplementary irrigation plus humic acid application on fruit yield, oil production and nutrient uptake of olive trees. Olive orchard located at Nabuls district, Palestine was used for conducting the field experiment during the growing period of 2011. Seventy-years-old olive trees "Souri cultivar" spaced at 10m×10m, were selected for the experiment. The field was divided into three treatments; with five replicates per each treatment. Each treatment has an area of one hectare with a plant density of 100 trees per hectare. Treatments consisted of application of three different irrigation water regimes as follows: Irrigation water plus humic acid, irrigation water only and no irrigation (rain-fed). Irrigation water was applied seven times at a rate of 430 l per tree, resulting in a total amount of three cubic meters per tree during summer months. Liquid organic fertilizer having 12% humic acid was applied with irrigation water once at a rate of 250cc per tree during the first irrigation application.
Results of this study indicated that, the fruit yield of treatment irrigated with water plus humic acid

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was 78kg per tree, and 56kg per tree for treatment irrigated with only water, while the rain-fed treatment gave only 36kg per tree. Moreover, the higher oil yield was observed under water plus humic acid application (16kg per tree), while the rain-fed gave only (6kg per tree). In addition to that, the mean fruit weight of treatment irrigated with water plus humic acid was 2.1g, and 1.6g for treatment irrigated with only water, while the rain-fed treatment was 1.1g.
The supplementary irrigation with three cubic meters of water per tree plus humic acid application have increased the fruit yield by 56.4% and oil yield by 62.5% compared to the rain-fed treatment.

*Keywords: Supplementary irrigation; humic acid; olive fruit; oil yield; rain-fed.*

## 1. INTRODUCTION

Olive tree (*Olea europaea L.*) is the most important fruit tree in Palestine covering approximately 45% of the Palestinian cultivated land; and 80% of the total area of fruit trees [1]. The tree is distinctly important in the economic and social life of the Palestinian people comprising one of the main sources of income, contributing to about 13% of the annual agriculture production [1]. Most of Palestinian areas are arid and semi-arid regions which indicate remarkable differences in the rate of precipitation. However, irrigation is a vital factor in improving production, productivity and quality of olive oil, even in areas where water is limited, since high quality olive oil cannot be obtained from olive fruit suffering from a high degree of water stress [2,3].

Most olive orchards in Palestine are rain-fed, except for small areas about 1500 hectares under full and supplementary irrigation in some areas in the west Bank and Gaza strip, because of water scarcity and land topography. The majorities of olive orchards are old (60 to few hundred years and in some sites over one thousand years) and consists mainly of Souri cultivar, where trees are spaced widely to take full advantage of stored soil water from winter rains for spring and summer growth.

In Palestine, during last few years olive orchards have been subjected to long drought periods and high temperature during summer and the high temperature increases the water evapotranspiration and reduces the availability of soil moisture for plant growth. During last few years the growth of olive orchards in Palestine under the above mentioned conditions have resulted in reduced yield of olive and bringing down the production of olive oil to 14 thousands tons [1]. It is found that the vegetative and root growth of olive trees are negatively affected by similar conditions of drought and high temperature [4]. Accordingly, the supplementary irrigation during the drought period could be a valuable tool for increasing the vegetative growth and yield production.

Several studies have indicated that irrigation of olive orchards resulted in a significant increase in yield production compared to rain-fed orchards depending on the climatic factors, variety, plant density, and other cultural practices [2,5-7]. Other studies indicated that the fruit size, pulp to stone ratio, endocarp size, percent of oil in fruit, were positively affected by supplementary irrigation [8-11].

Furthermore, recent researches indicated that it is not necessary to provide the full water requirements of olive trees, but what is required is to provide the essential water requirement during the specific growth period in order to avoid water stress and thus increase the olive fruit and oil production [2,12]. It is indicated that the irrigation treatment (33%, 66% or 100% of ETc) during the dry season significantly increased yield over rain-fed olives [5]. It is found that the irrigation of olive trees resulted in an increase in the fruit number per tree, total yield, weight of mesocarp, percent of oil in mesocarp at harvesting time [13]. Moreover, the study indicated that there were no significant differences in yield between the full irrigation treatment and the treatment irrigated at 46% of full water requirements.

Humic acid is a commercial product having elements which improve the soil fertility and increase the availability of nutrients and consequently affects plant growth and yield. There is a basic agreement on the benefits of humus, but there is quite a controversy on the benefit of application of applied humate (the deposits containing the humic acids). The application of humic acid has been reported to improve plant growth, increase fruit yield and its quality [14-18].

The objectives of this study were to investigate the effects of supplementary irrigation plus humic acid application on fruit yield, oil production and major nutrient uptake of olive trees.

## 2. MATERIALS AND METHODS

### 2.1 Experiment Description

A field study was conducted at olive orchard located at Nabuls district, Palestine during the year 2011, for studying the effects of supplementary irrigation plus humic acid application on fruit yield, oil production and major nutrient uptake of olive trees. The soil type at the site is loamy texture. The climate in the zone is typically Mediterranean with a mean annual precipitation of 600mm, concentrated mainly from autumn to spring. The warmer months are July/Augest and the coldest months are December/January. Most olive orchards are rain-fed, however, the amount and distribution of rainfall plays an important role in the annul yield production. The amount of rainfall during the year 2010-2011 was up to 570 mm (Fig. 1).

### 2.2 Treatments

Olive orchard was selected with an area of three hectares planted with Souri cultivar. Seventy-years-old olive trees spaced at 10m × 10m, were selected for the experiment. The field was divided into three treatments; with five replicates per each treatment. Each treatment has an area of one hectare, with a plant density of 100 trees per hectare, and 20 trees per replicate. Treatments consisted of application of three different irrigation water regimes as follows: (1) Irrigation water plus humic acid, (2) Irrigation water only and (3) No irrigation (rain-fed). Irrigation water was applied seven times at two weeks intervals at a rate of 430 l per tree, from July 15, 2011 until October 6, 2011 resulting in a total amount of three cubic meters per tree. Metal tanks with a capacity of 0.5 cubic maters were placed behind the trunk for irrigation water distribution through a hole placed at the bottom of the tanks. Liquid organic fertilizer having 12% humic acid was applied with irrigation water once at a rate of 250 cc per tree during the first irrigation application.

### 2.3 Measurements

Trees within the experimental plots were individually harvested by hand. Plant measurements were carried out at harvest and consisted of: fruit yield, oil content, pulp to fruit ratio, endocarp weight, pulp to stone ratio, individual fruit weight, number of fruit per tree, number of fruit per kg, number of fruit damage per tree, number of fruit damage per kg, and some selected macro and micronutrient of leaves tissues. Total nitrogen was determined by Kjeldahl method according to the procedure described by [19], phosphorus content was determined using spectrophotometer as described by [20], and potassium content was determined photo-metrically using flame photometer as described by [21]. A representative sample of one kg of fruits per tree was taken to determine fruit characteristics. Fruit size was estimated as 100 fruit weight per replicate. Pulp to stone ratio was measured after pitting a fruit sample of 100 fruits.

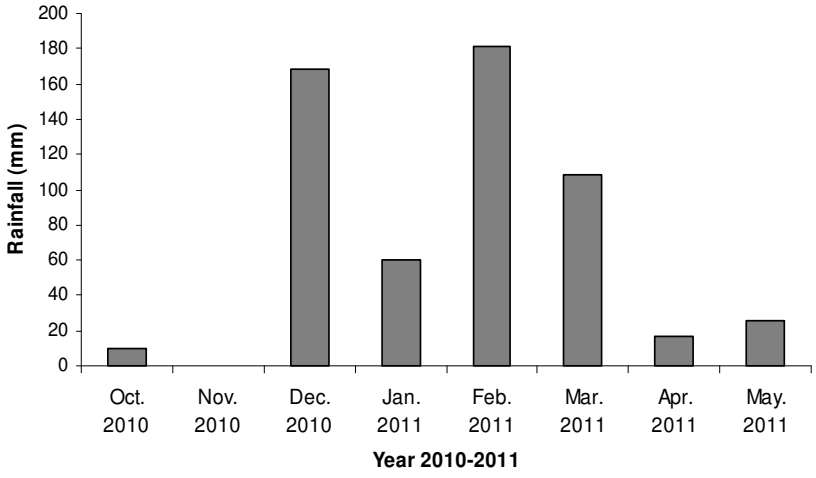


**Fig. 1. Monthly amount of rainfall in the experimental area during the year 2010-2011**

## 2.4 Statistical Analysis

The effects of irrigation regimes on fruit and oil yield of olive trees were analyzed using a randomized complete block design, using three treatments with five replicates per each treatment. Collected data in this study were analyzed and examined statistically using analysis of variance (ANOVA) from the Statistical Analysis System (SPSS). Means were compared by LSD test at 5% level of significance. The mean values of each treatment were designated by letters (a, b, c) which represent the significance degree of the difference between the means. Means represented by two letters in common indicate that the difference is not significant or weakly significant.

## 3. RESULTS AND DISCUSSION

## 3.1 Olive Yield

The water plus humic acid application had a profound influence on fruit yield. The mean fruit yield of treatment irrigated with water plus humic acid was 78kg per tree, and the treatment irrigated with only water reached up to 56kg per tree, while the rain-fed treatment gave only 34kg per tree (Fig. 2). These results indicated that the low amount of supplementary irrigation plus humic acid application have increased the olive yield production by 56.4% compared to the rain-fed treatment. In a field experiment it was observed that the applied water had a large influence on the olive tree growth, yield of fruit, its size and density [8].

In addition to that, results of this study indicated that the oil yield of treatment irrigated with water plus humic acid was 16kg per tree, and 12kg per tree for treatment irrigated with only water, while the rain-fed treatment gave only 6kg per tree (Table 1). These results explained by the increased fresh weight of mesocarps in fruits (1.56g) for treatment irrigated with water plus humic acid compared to the rain-fed treatment (0.67g) as given in Table 2. However, in another experiment a higher oil yield could be correlated to the increased pulp to stone ratio [5]. Statistical analysis given in Table 1 indicated that, there was a significant difference in fruit yield and oil yield between the three irrigation treatments according to LSD at 0.05 level.

Furthermore, these results indicated that no spots were seen on the fruits under treatment irrigated with water plus humic acid, while heavy spots clearly appeared on the fruits under the rain-fed treatment. This confirms that the rain-fed treatment was subjected to water stress during the growing period.

**Table 1. Fruit yield and oil production of olive trees**

| Treatments | Fruit yield (kg/tree) | Oil yield (kg/tree) | Oil content (% on FW) |
|---|---|---|---|
| Water plus humic acid | 78[c] | 16[c] | 20.5[ab] |
| Water | 56[b] | 12[b] | 21.4[b] |
| Rain-fed | 34[a] | 6[a] | 17.6[a] |

*Within columns means followed by the same letters are not significantly different according to LSD at 0.05 level*

## 3.2 Fruit Size (Weight)

The mean fruit weight under treatment irrigated with water plus humic acid was 2.1g, and 1.6g for only water treatment, while the rain-fed treatment was 1.1g (Fig. 3). However, an increase in fruit size with increasing amount of water has been previously reported [8,2,10]. The mean weight of fruit endocarp was 0.54, 0.47 and 0.43g for treatment irrigated with water plus humic acid, treatment irrigated with only water and the rain-fed treatment, respectively. These results indicated that, there were no significant differences between the endocarp fruit weight, although the supplementary irrigation induced the second stage of mesocarp growth.

Results also indicated that the pulp to fruit ratio reached up to 74, 71 and 61% for treatment irrigated with water plus humic acid, irrigation water and rain-fed treatments, respectively as given in Table 2. These results revealed that, the supplementary irrigation during the growth of mesocarp resulted in a significant increase in the pulp ratio which resulted in increased yield of oil.

## 3.3 Fruits Number

Results of this study indicated that the mean number of fruits per tree for treatment irrigated with water plus humic acid were more than that under rain-fed treatment (Table 3). Also results indicated that the fruits number per one kilogram for treatment irrigated with water plus humic acid were lower than that under rain-fed treatment. This reveals that the supplementary irrigation plus humic acid application increased the fruit

size which caused an increase in the total fruit yield production. Also results indicated that the percent of fruit damage for treatment irrigated with water plus humic acid were higher than that under rain-fed treatment as shown in Fig. 4. This highly number of fruit damage was probably due to the olive fly attach. This suggested that trees under water plus humic acid treatment were more prone to olive fly attacks as compared to other treatments. Moreover, high number of fruit damage was observed early at rain-fed treatment due to water stress during the growing period.

## 3.4 Nutrients Uptake

Some selected macro and micronutrients (N, P, K, Fe, Zn, Mn and Cu) were analyzed in leaves tissues under different irrigation treatments and given in Table 4. Results of this study indicated that the major macronutrients (N, P and K) of leaves tissues under treatment irrigated with water plus humic acid were lower than that under rain-fed treatments. This may be explained by the positive increase of nutrients assimilation under humic acid application.

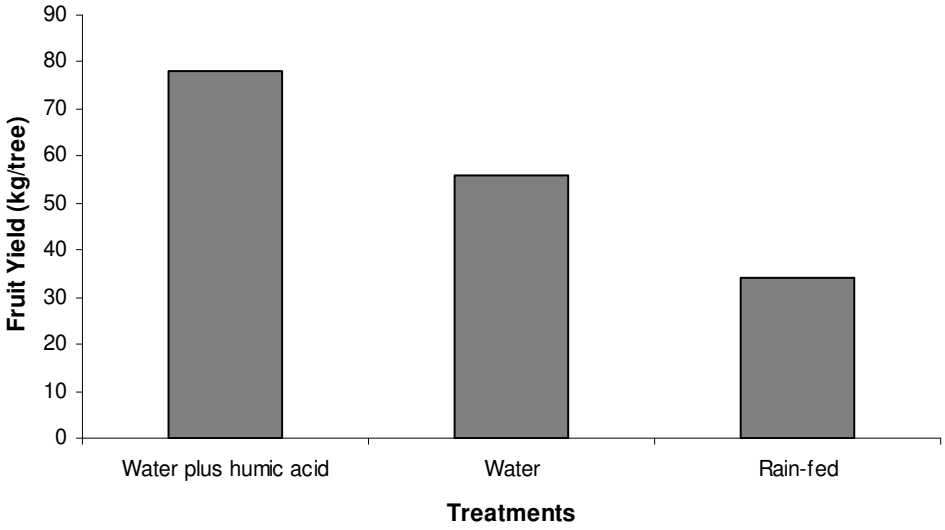


**Fig. 2. Mean fruit yield of olive trees under different irrigation treatments**

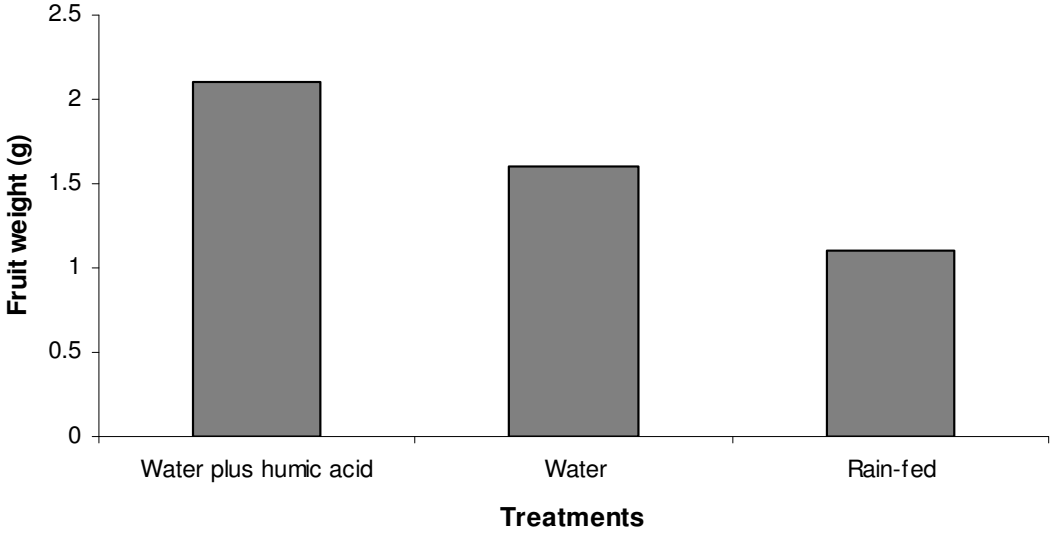


**Fig. 3. Individual fruit weight of olive trees under different irrigation treatments**

**Table 2. Mean fruit weight, endocarp and mesocarp weight of olive fruits**

| Treatments | Fruit weight (g) | Endocarp weight (g) | Mesocarp weight (g) | Pulp to fruit ratio (%) | Stone to fruit ratio (%) | Pulp to stone ratio |
|---|---|---|---|---|---|---|
| Water plus humic acid | 2.1 | 0.54 | 1.56 | 74 | 26 | 2.8 |
| Water | 1.6 | 0.47 | 1.13 | 71 | 29 | 2.4 |
| Rain-fed | 1.1 | 0.43 | 0.67 | 61 | 39 | 1.5 |

**Table 3. Mean fruits number and fruit damage per tree under different irrigation treatments**

| Treatments | No of fruits per tree | No of fruits per kg | No of fruit damage per tree | No of fruit damage per kg | % of fruit damage per tree |
|---|---|---|---|---|---|
| Water plus humic acid | 31200$^{b}$ | 400$^{a}$ | 3300$^{c}$ | 660$^{a}$ | 10.5$^{c}$ |
| Water | 33700$^{c}$ | 556$^{b}$ | 2500$^{b}$ | 833$^{b}$ | 7.4$^{a}$ |
| Rain-fed | 22600$^{a}$ | 667$^{c}$ | 2000$^{a}$ | 1000$^{a}$ | 8.8$^{b}$ |

*Within columns means followed by the same letters are not significantly different according to LSD at 0.05 level*

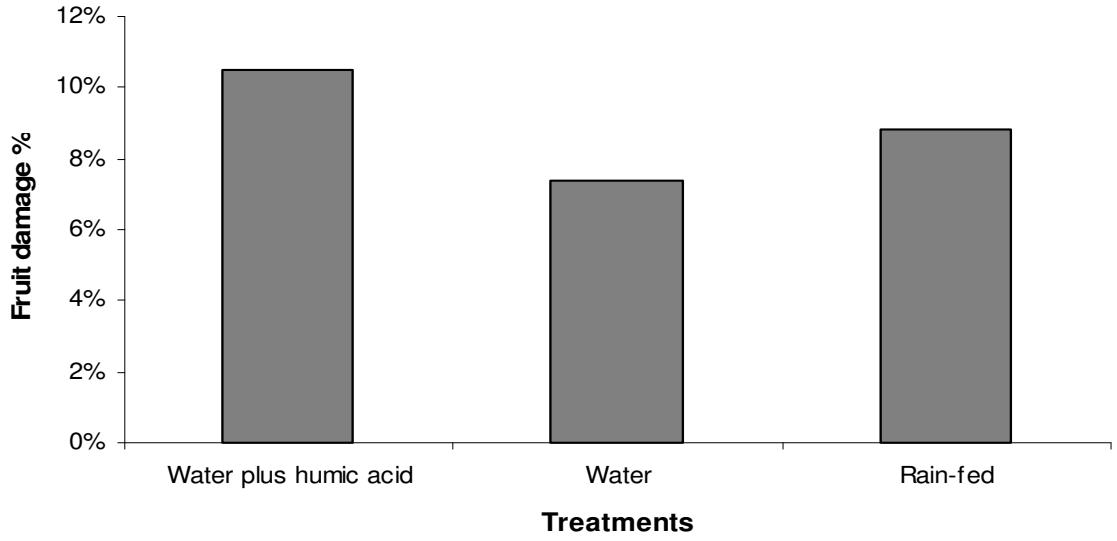


**Fig. 4. Percent of fruit damage under different irrigation treatments**

**Table 4. Some selected macro and micronutrient of leaves tissues**

| Treatments | N (%) | P (%) | K (%) | Fe (ppm) | Zn (ppm) | Mn (ppm) | Cu (ppm) |
|---|---|---|---|---|---|---|---|
| Water plus humic acid | 1.24 | 0.072 | 0.20 | 142.6 | 14.4 | 53 | 5.1 |
| Water | 1.29 | 0.084 | 0.24 | 121 | 15 | 45 | 4.8 |
| Rain-fed | 1.40 | 0.098 | 0.26 | 131 | 16.6 | 49.4 | 5.9 |

## 4. CONCLUSION

This investigation study indicates that supplementary irrigation plus humic acid application have large influence on olive tree growth, including fruit yield, oil yield, fruit size and mesocarp weight. The supplementary irrigation with three cubic meters per tree plus humic acid application have increased the fruit yield by 56.4% and oil yield by 62.5% compared to the rain-fed treatment. The mean fruit weight of treatment irrigated with water plus humic acid was 2.1g, and 1.6g for treatment irrigated with only water, while the rain-fed treatment was 1.1 g. Results also indicated that pulp to fruit ratio reached up to 74, 71 and 61% for treatment

irrigated with water plus humic acid, irrigation water and rain-fed treatments, respectively.

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## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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