# Effect of Zinc and Boron on Vegetative Growth, and Fruiting of Manzanillo Olive Tree under Siwa Oasis Conditions

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## ABSTRACT

**This study was carried out during 2018 and 2019 seasons on Manzanillo cv. olive trees (*Olea europaea* L.) located at Siwa Oasis, trees were planted at 5x5 meters apart in sandy soil, under surface irrigation system. The trial was conducted as split plot design with three replication, zinc sulphate in main plots (2 g/l, 4 g/l and 6g/l) and boric acid (1.5 g/l, 3 g/l and 4.5 g/l) located in the subplots, foliar sprays of zinc sulphate and boric acid treatments at two times i.e., the first was done before flowering on end of February and the second one was 1st May to compare an effects on vegetative growth, flowering, and fruiting on olive trees. The results showed that vegetative growth i.e tree height, both the circumference and diameter, shoot growth, leaf characteristics (length, width and area of leaf blade), flowering characteristics (Panicles number per shoot, number of flower per panicle and perfect flower percentage), fruit setting (initial fruit set percentage and the initial number of fruitlets), recorded the highest values with higher both zinc sulphate and boric acid treatments. Subsequent fruit retention (%) from the first of June until to the first of October were recorded the highest values with zinc sulphate 6 g/L or 4 g/L, plus boric acid 4.5g/L or 3 g/L, the lowest values were recorded with zinc sulphate 2 g/L plus boric acid 1.5 g/L.**

**Keyword: Manzanillo - Olive - Zinc - Boron - Vegetative growth - Flowering - Fruit set.**

## INTRODUCTION

Olive is a member of the *Oleaceae* family, genus *Olea*. Commercial olive trees belong to *Olea europaea* L., the only species which produces edible fruits. The olive tree is originated Mediterranean-type climate, it has been cultivated for its oil and fruit (Bertrand, 2002). Siwa Oasis, it located in Marsa Matruh, western Egypt. It lies near the Libyan frontier, Siwa Oasis is considered an appropriate region for olive production on a large scale (Hedia and Abd Elkawy, 2016).

Zinc and boron are soluble in water, so it is easily lost with irrigation water, it is absorbed and replaced in the colloidal part thus it decreases in lands with low organic matter content, also these deficiency are common in high-pH soils (Storey *et al.,* 1971; Graham *et al.,* 1992; White & Zasoski, 1999 and Tavallali & Rahemi, 2007). So, zinc and boron deficiency are common in the study area because it is sandy land with poor organic matter content, depends on surface irrigation and located in arid region. Spanich cv. Manzanillo is the most important commercial variety entered in Siwa Oasis especially in the last two decades.

Zinc has an enzymatic and reactive function by involving in the catalytic function of the enzyme and zinc has binding sites wide range with other proteins, membrane lipids and DNA (Klug, 1999 and Englbrecht *et al.,* 2004). Zn deficiency effect on pollen production and pollen physiology (Usenik & Stampar, 2002 and Ute & Clemens, 2005), it is closely involved in pollen tube growth resulted from its role on tryptophan synthesis as an auxin precursor biosynthesis (Alloway, 2004 and Hassan *et al.,* 2010). Moreover, zinc is related to fruit set and fertilization, its role to flowering enhancement (Sotomayor *et al.,* 2002). Foliar applications of Zn successes and promote to tree vigor and fruit set, in apple (Wojcik, 2007) and 'Washington Navel' orange (Hafez and El-Metwally, 2007).

The boron requirement is much higher for increases flower production and retention, pollen tube elongation and germination (Peres and Reyes, 1983). Boron has been playing an essential role in fertility (Christensen *et al.,* 2016) and increase pollen germination in a number of tree species including almond *Prumus amygdalus* (Nyomora *et al.,* 1997), pear Pyrus communis (Lee *et al.,* 2009), and fruit set in almond, sweet cherry (*Prunus avium*), hazelnut (*Corylus avellana*) and apple (*Malus ·domestica*) (Shrestha *et al.*, 1987; Nyomora et al., 1997; Usenik and Stampar, 2002; Silva *et al.*, 2003 and Wojcik &Treder, 2006). Boron deficiency causes reduced pollen production and poor fruit set. Because, boron is required in stigma and styles to physiologically inactivate callus present in pollen tube walls (Lewis, 1980), which significantly enriched the developing olive flowers, and growing shoots (Perica *et al.,* 2001). So, the suitable time of boron foliar application is before flowering and effective for fruit development. Furthermore, boron is highly needed for reproductive growth in many crops (Bybordi & Malakouti, 2009 and Hanson, 1991). For deciduous species, boron application increases fruit set in nut crops and olive trees (Perica *et al.,* 2001; Hanson, 1991 and Nyomora *et al.,* 1999). Boron foliar application increased fruit set in olive cultivars such as "Manzanillo" (Perica *et al.,* 2001and Hussein & Abd-Elall, 2018), "Koronaiki" and "Boutilan" (Desouky *et al.,* 2009), navel oranges

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(Maurer and Taylor, 1999) and Pear "Conference" (Wojcik and Marzena, 2003).

Zinc and boron have important role on pollination and fruit set (Motesharezade *et al.*, 2001 and Bybordi & Malakout, 2006). Saadati *et al. (*2016) found that foliar application of zinc and/or boric acid significantly increased fruit set. Talaie *et al.* (2001) showed that foliar spray of B and Zn decreased fruit drop in the 'Zard' olive, Osman (1999) found that boron treatments either as foliar or soil applications increased percentage of retained fruits on olive trees. Foliar B and Zn have both been observed to increase vegetative growth in mango (*Mangifera indica*) when trees were sprayed with 800 $mgL^{-1}$ Zn (Rajput *et al.*, 1976) and have positive effects on chlorophyll contents (Kaya & Higgs, 2002 and Zheng *et al.,* 1989). Foliar applications of zinc sulphat in combination with boric acid were resulted better growth cultivar Frontoio (Amit *et al.,* 2014). Ghani *et al*. (2017), boron concentrations at 600 ppm foliar spray was recorded maximum number of flowers per panicle, perfect flowers and number of fruits per panicle. Maksoud *et al.* (2004) and Eassa (2006), they indicated that boron foliar application significantly increased the tree growth of Manzanillo and Picual olive cultivars.

The aim of the present research was to study the effect of foliar spraying of zinc sulphate and boric acid on vegetative growth, and fruiting of Manzanillo olive tree under Siwa conditions.

## MATERIAL AND METHODS

The experimental field was located in a private orchard at Siwa Oasis, Marsa Matru, Egypt (29.21 N longitude, 25.40 E and 18 meter below sea level). This experiment was conducted during of 2018 and 2019 seasons on eleven years old "Manzanillo" olive trees planted in sandy soil, grown at (5X5 meter) apart.

Soil was analyzed by using the methods described by Chapman and Pratt (1978) that included sand (91.90 %), silt (5.25%) and clay (1.85%). The texture of experimented soil is sandy and have pH (7.8), EC (1.4 $dsm^{-1}$), organic matter (0.5%), soluble anions $HCO_3^-$ (6 meq/l), $Cl^-$ (31.3 meq/l), $SO_4^{--}$ (6.1 meq/l) and soluble cations $Ca^{++}$ (8.6 meq/l), $Mg^{++}$ (7.5 meq/l), $Na^+$ (0.2 meq/l) and $K^+$ (24.7 meq/l). While the chemical analysis of ground water of the experiment pH (7.02), EC (4.1 $dsm^{-1}$), soluble anions $HCO_3^-$ (1.50 meq/l), $Cl^-$ (15.61 meq/l), $SO_4^{--}$ (20.13 meq/l) and soluble cations $Ca^{++}$ (10.42 meq/l), $Mg^{++}$ (7.83 meq/l), Na+ (18.72 meq/l) and $K^+$ (0.65 meq/l). Trees with uniform vigor were selected for foliar application treatments. Annual fertilizers per feddan: 25 $m^3$ organic manure, 200 Kg super phosphate (15% $P_2O_2$), 500 Kg ammonium sulphate (20.5 % N) and 200 Kg potassium sulphate (45 % $K_2O$).

This investigation was considered a Factorial experiment as it included two factors as follows: 1- Three foliar sprays treatments were imposed of zinc sulphate ($Zn_2SO_4.H_2O$ 36%) that applied various treatments at concentrations of 2 g/l, 4 g/l and 6g/l (0.20, 0.40 and 0.60%). 2- Boric acid ($H_2BO_3$) was applied at three concentrations as follows: 1.5 g/l, 3 g/l and 4.5 g/l (0.15, 0.3 and 0.45%) in three replications. Foliar sprays of zinc sulphate and boric acid treatments were carried out at two times i.e., the first foliar sprays was done before flowering on end February and the second one was 1st May. Tween-20 was added at 0.1% as a surfactant to spray solution. Spraying was carried out using compression sprayers (5L solution/tree) at the previously mentioned dates.

Response of Manzanillo olive trees to the tested zinc sulphate and boric acid treatments were evaluated through the following parameters.

**Morphological characteristics:**

**Tree dimensions (cm):**

Tree height, both the circumference and diameter were measured using meter scale initial measure were in early February and final measure in early November.

**Shoot growth:**

To estimate rate of shoot elongation, twenty new shoots per tree were randomly selected and tagged in early February till growth stopped in early November and total number of leaves per shoot were counted and recorded.

**Leaf characteristics:**

Leaf length, width and area for 20 mature leaves on spring cycle shoots, were estimated by using Portable area mod Li 3100 Ali (Li-cor) in September.

**Flowering characteristics.**

**Number of panicles per shoot**. Pre- full bloom stage 20 shoot one year-old were chosen at random on each tree for recording number of panicles per shoot.

**Number of flower per panicle:** Samples of 30 panicles from each tree (just before flower opening) were picked to determine average number of flowers per panicle.

**Perfect flower%:**

Samples of 30 panicles for each tree were taken at full bloom stage number of total and perfect flowers in each panicle were counted and the percentage of perfect flowers to total number of flowers was calculated.

**Fruit setting:**

**Initial fruit set:** To estimate the percentage of initial fruit set for each tree, twenty shoots (one-year-old) per tree were selected and tagged at random during the full blooming stage. The number of flowering on each shoots was counted and recorded.

**The initial number of fruitlets**: Number of fruitlets was recorded after 5 days from the end of blooming period. The number of fruitlets and sequence fruits on their shoots was counted at monthly intervals till the time of harvest for each tree.

**Statistical analysis:**

The obtained data of 2018 and 2019 seasons were subjected to analysis of variance according to Clarke and Kempson (1997). Means were differentiated using Duncan multiple rang test at the 0.05 level (Duncan, 1955).

## RESULTS AND DISCUSSION

**Morphological characteristics:**

**Tree dimensions:**

**Increment tree height (cm):**

Table,1 illustrate that zinc sulfate foliar sprays at concentrations 6 g/L resulted in the highest increment in tree height followed descending by 4 g/L and 2 g/L concentrations in the two seasons of study.

Moreover, the highest increment in tree height was recorded with boric acid 4.5 g/L followed by 3 g/L and 1.5 g/L concentrations respectively.

Concentration of 6 g/L zinc sulphate combined with 4.5 g/L boric acid concentration proved to be the best interaction in this regard.

**Increment in circumference (cm):**

Table (2) shows that zinc sulphate concentration at 6 g/L gave the highest increment in circumference value followed by, 4 g/L zinc sulphate concentration in descending order. Meanwhile, the lowest increment in circumference value was recorded with zinc sulphate concentration at 2 g/L in both seasons.

In addition, boric acid the highest increment in circumference value was recorded with boric acid concentration at 4.5 g/L followed by 3 g/L and 1.5 g/L which recorded the lowest values in this respect.

The combined effects of zinc sulphate with boric acid concentrations showed that 6 g/L concentration of zinc sulphate with 4.5 g/L boric acid concentration were the most effective concentrations increment in circumference, finally by the corresponding ones of 2 g/L zinc sulphate combined with 1.5 g/L boric acid the less effective in circumference.

**Table 1. Effect of zinc sulphate and boric acid on increment tree height (cm) of Manzanillo olive trees during 2018 and 2019 seasons**

| Zinc sulphate | Boric acid | | | | Boric acid | | | |
|---|---|---|---|---|---|---|---|---|
| | 1.5 g/L | 3 g/L | 4.5 g/L | Mean | 1.5 g/L | 3 g/L | 4.5 g/L | Mean |
| | 2018 | | | | 2019 | | | |
| 2 g/L | 12.45 i | 13.49 f | 13.90 e | 13.28 C | 20.92 h | 22.29 f | 22.39 e | 21.86C |
| 4 g/L | 12.74 h | 14.42 d | 14.83 c | 13.99 B | 21.53 g | 23.74 d | 24.84 c | 23.37B |
| 6 g/L | 13.20 g | 15.50 b | 16.20 a | 14.97 A | 21.54 g | 25.30 b | 25.80 a | 21.86A |
| Mean | 12.79 C | 14.47 B | 14.97 A | | 21.33 C | 23.81 B | 24.31 A | |

Means within each column or row followed by the same letter (s) are not significantly at 5% level.

**Table 2. Effect of zinc sulphate and boric acid on increment in circumference (cm) of Manzanillo olive trees during 2018 and 2019 seasons**

| Zinc sulphate | Boric acid | | | | Boric acid | | | |
|---|---|---|---|---|---|---|---|---|
| | 1.5 g/L | 3 g/L | 4.5 g/L | Mean | 1.5 g/L | 3 g/L | 4.5 g/L | Mean |
| | 2018 | | | | 2019 | | | |
| 2 g/L | 10.47 g | 11.42 e | 11.73 d | 11.20 C | 14.10 i | 16.10 f | 17.11 e | 15.77C |
| 4 g/L | 10.49 g | 11.87 c | 11.91 c | 11.42 B | 14.63 h | 17.63 d | 17.72 c | 16.66B |
| 6 g/L | 11.19 f | 12.37 b | 12.45 a | 12.00 A | 15.40 g | 19.41 b | 19.47 a | 18.09A |
| Mean | 10.71 C | 11.88 B | 12.03A | | 14.71C | 17.71B | 18.10A | |

Means within each column or row followed by the same letter (s) are not significantly at 5% level.

**Increment in diameter (cm):**

Table (3) indicates that zinc sulphate at 6 g/L concentration recorded the highest increment in diameter value followed by zinc sulphate at 4 g/L concentration and zinc sulphate at 2 g/L concentration, respectively in both seasons.

Furthermore 4.5 g/L boric acid concentration gave the highest increment in diameter followed by 3 g/L and 1.5 g/L concentrations in both seasons.

The interaction between zinc sulphate and boric acid concentrations reveals that the highest increment in diameter value was recorded with 6 g/L zinc sulphate supported with 4.5 g/L boric acid concentrations. On the contrary, the combination of 2 g/L zinc sulphate and 1.5 g/L boric acid gave the least positive effect on increment in diameter.

**Shoot growth:**

**Increment in shoot length (cm):**

Results in Table (4) refers to the highest shoot length was found with olive trees treated by highest concentrations of both zinc sulphate and boric acid in both seasons. A gradual significant increase in shoot length was noticed with increase of concentration of both zinc and boron in the experimental seasons.

Furthermore, Table (4) shows that boric acid at 4.5 g/L concentration gave the highest increment in shoot length followed by 3 g/L and 1.5 g/L concentrations in the both seasons,

The interaction between zinc sulphate and boric acid concentrations illustrates that the highest increment in shoot length was recorded by high zinc sulphate (6 g/L) in combination with (4 g/L) boric acid concentrations. The lowest increment in shoot length was recorded when the low zinc sulphate concentration was combined with 1.5 g/L boric acid concentration.

**Leaf characteristics:**

**Increment in number of leaves per shoot:**

Data presented in Table (5) shows that the highest increment in number of leaves per shoot values were recorded with 6 g/L zinc sulphate followed by zinc sulphate at 4 g/L and 2 g/L, respectively.

Furthermore, the highest increments in number of leaves per shoot were recorded with 4.5g/L followed by 3 g/L and 1.5 g/L concentration of boric acid in the two seasons.

The interaction effect of zinc sulphate and boric acid concentration proved that the highest increment in number of leaves per shoot were scored with zinc sulphate 6 g/L plus 4.5 g/L, while the lowest values were recorded with 2 g/L zinc sulphate combined with 1.5 g/L boric acid.

**Table 3. Effect of zinc sulphate and boric acid on increment in diameter (cm) of Manzanillo olive trees during 2018 and 2019 seasons**

| Zinc sulphate | Boric acid | | | | Boric acid | | | |
|---|---|---|---|---|---|---|---|---|
| | 1.5 g/L | 3 g/L | 4.5 g/L | Mean | 1.5 g/L | 3 g/L | 4.5 g/L | Mean |
| | 2018 | | | | 2019 | | | |
| 2 g/L | 9.12 i | 10.19 f | 10.72 e | 10.01 C | 18.17 i | 19.93 e | 19.32 f | 19.14C |
| 4 g/L | 9.42 h | 11.09 d | 11.40 c | 10.63 B | 18.76 h | 20.42 d | 21.74 c | 20.30B |
| 6 g/L | 9.83 g | 12.38 b | 12.67 a | 11.62 A | 19.00 g | 22.43 b | 23.69 a | 21.70A |
| Mean | 9.45 C | 11.22 B | 11.59A | | 18.64C | 20.92B | 21.58A | |

Means within each column or row followed by the same letter (s) are not significantly at 5% level

**Table 4. Effect of zinc sulphate and boric acid on increment in shoot length (cm) of Manzanillo olive trees during 2018 and 2019 seasons**

| Zinc sulphate | Boric acid g/L | | | | Boric acid | | | |
|---|---|---|---|---|---|---|---|---|
| | 1.5 g/L | 3 g/L | 4.5 g/L | Mean | 1.5 g/L | 3 g/L | 4.5 g/L | Mean |
| | 2018 | | | | 2019 | | | |
| 2 g/L | 1.65 g | 1.80 e | 1.86 d | 1.77 C | 6.02 i | 6.75 f | 7.25 e | 6.67 C |
| 4 g/L | 1.71 f | 1.89 d | 2.04 c | 1.88 B | 6.19 h | 7.41 d | 7.65 c | 7.08 B |
| 6 g/L | 1.77 e | 2.20 b | 2.35 a | 2.11 A | 6.28 g | 7.78 b | 7.84 a | 7.30 A |
| Mean | 1.71 C | 1.96 B | 2.08 A | | 6.16 C | 7.31 B | 7.58 A | |

Means within each column or row followed by the same letter (s) are not significantly at 5% level

**Table 5. Effect of zinc sulphate and boric acid on increment in number of leaves per shoot of Manzanillo olive trees during 2018 and 2019 seasons**

| Zinc sulphate | Boric acid | | | | Boric acid | | | |
|---|---|---|---|---|---|---|---|---|
| | 1.5 g/L | 3 g/L | 4.5 g/L | Mean | 1.5 g/L | 3 g/L | 4.5 g/L | Mean |
| | 2018 | | | | 2019 | | | |
| 2 g/L | 3.10 i | 3.76 f | 3.90 e | 3.58 C | 16.69 i | 18.67 f | 19.73 e | 18.37C |
| 4 g/L | 3.26 h | 4.18 d | 4.27 c | 3.90 B | 17.42 h | 20.22 d | 20.49 c | 19.38B |
| 6 g/L | 3.57 g | 4.82 b | 5.09 a | 4.49 A | 18.10 g | 21.28 b | 21.47 a | 20.28A |
| Mean | 3.31 C | 4.25 B | 4.42 A | | 17.40C | 20.06B | 20.56A | |

Means within each column or row followed by the same letter (s) are not significantly at 5% level.

**Leaf length (cm):**

Table (6) demonstrates that increasing zinc sulphate from 2 g/L to 4 g/L and 6 g/L concentrations caused a steady increase in leaf length in both seasons.

Furthermore, it is clear that 4.5 g/L boric acid concentration recorded the highest leaf length followed by 3 g/L and 1.5 g/l concentrations.

Moreover, the interaction between zinc sulphate and boric acid concentrations showed that zinc sulphate at 6 g/L supplemented with 4.5 g/L boric acid scored the highest values of leaf length, while the lowest value was recorded with the combination of zinc sulphate 2 g/L and 1.5 g/L boric acid concentration. Other interaction scored in between rather in this respect.

**Leaf width (cm):**

Table (7) illustrates that 6 g/L zinc sulphate concentration gave the highest leaf width followed discerningly by 4 g/L zinc sulphate. Meanwhile, zinc sulphate at 2 g/L recorded the lowest leaf width.

Furthermore, it is evident that the highest leaf width was recorded with 4.5 g/L followed by 3 g/L and 1.5 g/L concentrations.

In addition, zinc sulphate at 6 g/L combined with 4 g/L boric acid concentration proved to be the most effective treatment in improving leaf width. On the contrary, 2 g/L zinc sulphate combined with boric acid concentration 1.5 g/L gave comparatively the lowest values in this respect.

**Table 6. Effect of zinc sulphate and boric acid on leaf length (cm) of Manzanillo olive trees during 2018 and 2019 seasons**

| Zinc sulphate | Boric acid | | | | Boric acid | | | |
|---|---|---|---|---|---|---|---|---|
| | 1.5 g/L | 3 g/L | 4.5 g/L | Mean | 1.5 g/L | 3 g/L | 4.5 g/L | Mean |
| | 2018 | | | | 2019 | | | |
| 2 g/L | 5.14 g | 5.41 e | 5.46 d | 5.34 C | 5.31 f | 5.49 d | 5.52 d | 5.45 C |
| 4 g/L | 5.24 f | 5.56 c | 5.60 bc | 5.47 B | 5.34 ef | 5.57 c | 5.74 b | 5.54 B |
| 6 g/L | 5.37 e | 5.61 b | 5.68 a | 5.55 A | 5.36 e | 5.89 a | 5.91 a | 5.72 A |
| Mean | 5.25 C | 5.53 B | 5.58 A | | 5.34 C | 5.65 B | 5.72 A | |

Means within each column or row followed by the same letter (s) are not significantly at 5% level.

**Table 7. Effect of zinc sulphate and boric acid on leaf width (cm) of Manzanillo olive trees during 2018 and 2019 seasons**

| Zinc sulphate | Boric acid | | | | Boric acid | | | |
|---|---|---|---|---|---|---|---|---|
| | 1.5 g/L | 3 g/L | 4.5 g/L | Mean | 1.5 g/L | 3 g/L | 4.5 g/L | Mean |
| | 2018 | | | | 2019 | | | |
| 2 g/L | 1.80 f | 1.91 d | 1.92 cd | 1.87 C | 1.96 f | 2.06 d | 2.0 7cd | 2.03 C |
| 4 g/L | 1.84 e | 1.94 bcd | 1.96 bc | 1.91 B | 2.00 e | 2.08 cd | 2.11 bc | 2.06 B |
| 6 g/L | 1.86 e | 1.97 b | 2.04 a | 1.96 A | 2.05 d | 2.13 b | 2.21 a | 2.13 A |
| Mean | 1.83 C | 1.94 B | 1.97 A | | 2.00 C | 2.09 B | 2.13 A | |

Means within each column or row followed by the same letter (s) are not significantly at 5% level.

**Leaf area (cm$^3$):**

Table (8) indicates that increasing zinc sulphate concentration and boric acid concentration results in increasing leaf area in both seasons.

Furthermore, zinc sulphate at 6 g/L plus 4.5 g/L boric acid proved to be the most effective combination in this respect in the two seasons.

Concerning, the positive results of zinc sulphate and boric acid concentrations in harmony with previous studies of zinc sulphate and boric acid reported by Wojcik (2007) and Hafez & El-Metwally (2007) they found that the foliar applications of Zn successes in promote to tree vigor. Perica *et al.* (2001) indicated that boron significantly was enriched growing shoots. Moreover, Hanson (1991) and Baybordi & Malakouti (2006) conducted that boron needed for reproductive growth in many crops. Perica *et al.* (2001) found that boron is effective on growing shoots

The enhanced effect of zinc sulphate concentrations on all plant growth parameters such as tree height, diameter, circumference, number of leaves per shoot, shoot length, leaf number leaf width, leaf length and leaf area may be due to the role of zinc has an enzymatic and reactive function by involving in the catalytic function of the enzyme and zinc has binding sites wide range with other proteins, membrane lipids and DNA (Klug, 1999 and Englbrecht *et al.,* 2004).

Results are in harmony with those studies which used foliar B and Zn have been observed to increase vegetative growth in mango (*Mangifera indica*) when trees were sprayed with 800 mgL$^{-1}$ Zn (Rajput *et al.*, 1976), and have positive effects on chlorophyll contents (Kaya & Higgs, 2002 and Zheng *et al.*, 1989). Amit *et al. (*2014) found that foliar application of zinc sulphate in combination with boric acid were resulted better growth of cultivar Frontoio olive tree.

**Flowering characteristics:**

**Number panicles per shoot:**

Table (9) shows that number panicles per shoot was significantly affected by zinc sulphate and boric acid concentrations. Zinc sulphate at 6 g/L gave the highest number panicles per shoot followed by 4 g/L and 2 g/L.

Concerning boric acid, the highest number panicles per shoot was recorded with 4.5 g/L significantly followed by 3 g/L and 1.5 g/L.

Zinc sulphate at 6 g/L with 4 g/L boric acid concentration proved to be the most effective interaction in increasing number panicles per shoot. On the contrary, zinc sulphate at 2 g/L provided with 1.5 g/tree boric acid gave comparatively the lowest value in this concern.

**Table 8. Effect of zinc sulphate and boric acid on leaf area (cm3) of Manzanillo olive trees during 2018 and 2019 seasons**

| Zinc sulphate | Boric acid | | | | Boric acid | | | |
|---|---|---|---|---|---|---|---|---|
| | 1.5 g/L | 3 g/L | 4.5 g/L | Mean | 1.5 g/L | 3 g/L | 4.5 g/L | Mean |
| | 2018 | | | | 2019 | | | |
| 2 g/L | 3.19 f | 3.27 e | 3.39 d | 3.25 C | 3.30 f | 3.45 d | 3.53 | 3.44 C |
| 4 g/L | 3.12 g | 3.47 c | 3.47 c | 3.35 B | 3.33 f | 3.66 c | 3.68 bc | 3.55 B |
| 6 g/L | 3.11 g | 3.54 b | 3.59 a | 3.44 A | 3.45 e | 3.72 b | 3.81 a | 3.66 A |
| Mean | 3.14 C | 3.42 B | 3.48 A | | 3.36 C | 3.63 B | 3.67 A | |

Means within each column or row followed by the same letter (s) are not significantly at 5% level.

**Table 9. Effect of zinc sulphate and boric acid on number of panicles per shoot of Manzanillo olive trees during 2018 and 2019 seasons**

| Zinc sulphate | Boric acid | | | | Boric acid | | | |
|---|---|---|---|---|---|---|---|---|
| | 1.5 g/L | 3 g/L | 4.5 g/L | Mean | 1.5 g/L | 3 g/L | 4.5 g/L | Mean |
| | 2018 | | | | 2019 | | | |
| 2 g/L | 8.57 h | 8.87 e | 8.93 d | 8.79 C | 8.92 i | 9.42 f | 9.50 e | 9.84 A |
| 4 g/L | 8.67 g | 8.93 d | 9.05 c | 8.88 B | 9.26 h | 9.68 d | 9.89 c | 9.61 B |
| 6 g/L | 8.86 f | 9.10 b | 9.17 a | 9.01 A | 9.37 g | 10.05 b | 10.10 a | 9.28 C |
| Mean | 8.66 C | 8.96 B | 9.05 A | | 9.18 C | 9.71 B | 9.83 A | |

Means within each column or row followed by the same letter (s) are not significantly at 5% level.

**Number flower per panicle:**

Table (10) illustrate zinc sulphate concentration at 6 g/L resulted in the highest number flower per panicle followed descending by 4 g/L and 2 g/L concentration in the two seasons, respectively.

Moreover, the highest number flower per panicle was recorded with 4.5 g/L followed by 3 g/L and 1.5 g/L boric acid concentrations, respectively

Concerning the interaction between the tested zinc sulphate, and boric acid concentrations, 6 g/L zinc sulphate combined with 4.5 g/L boric acid proved to be the best interaction in this regard.

**Number of perfect flowers per panicle:**

Table, (11) shows that zinc sulphate at 6 g/L gave the highest number of perfect flowering per panicle followed by 4 g/L zinc sulphate concentration.

Meanwhile, the lowest number of perfect flowering per panicle value was recorded with 2 g/L zinc sulphate in both seasons.

In addition, the highest number of perfect flowering value was recorded with 4 g/L boric acid followed by 3 g/L and 1.5 g/L which recorded the lowest values in this respect. The combined effects of zinc sulphate with boric acid concentration showed that 6 g/L of zinc sulphate with 4.5 g/L boric acid concentration were the most effective treatment in increasing number of perfect flowering per panicle. Finally, by the corresponding ones of 2 g/L zinc sulphate combined with boric acid 1.5 g/L was the least effective number of perfect of flower per panicle.

**Fruit setting:**

**Initial fruit set (%):**

Data of initial fruit set it is clear from Table (12) that zinc sulphate at 6 g/L produced the highest initial fruit set (%) as compared with those given with 2 g/L zinc sulphate in both seasons. On the other hand, 4 g/L zinc sulphate gave an intermediate effect in this respect.

Furthermore, Table (12) shows that boric acid at 4.5 g/L concentration gave the highest initial fruit set (%) followed by 3 g/L and 1.5 g/L concentrations in the both seasons,

The interaction between zinc sulphate and boric acid concentrations illustrates that the highest initial fruit set (%) was recorded by high zinc sulphate (6 g/L) provided with (4.5 g/L) boric acid concentrations. The lowest initial fruit set value was recorded when the low zinc sulphate concentration was combined with 1.5 g/L boric acid concentration.

**Table 10. Effect of zinc sulphate and boric acid on number of flower per panicle of Manzanillo olive trees during 2018 and 2019 seasons**

| Zinc sulphate | Boric acid | | | | Boric acid | | | |
|---|---|---|---|---|---|---|---|---|
| | 1.5 g/L | 3 g/L | 4.5 g/L | Mean | 1.5 g/L | 3 g/L | 4.5 g/L | Mean |
| | 2018 | | | | 2019 | | | |
| 2 g/L | 13.37 h | 13.57 f | 13.73 e | 13. 56C | 13.56 g | 13.65 f | 13.88 e | 13.69C |
| 4 g/L | 13.51 g | 13.84 d | 13.94 c | 13.76 B | 13.61 f | 13.99 d | 14.09 c | 13.89B |
| 6 g/L | 13.55 fg | 14.08 b | 14.23 a | 13.95 A | 13.62 f | 14.24 b | 14.36 a | 14.07A |
| Mean | 13.47 C | 13.83 B | 13.96A | | 13.59C | 13.96B | 14.11A | |

Means within each column or row followed by the same letter (s) are not significantly at 5% level.

**Table 11. Effect of zinc sulphate and boric acid on number of perfect flowers per panicle of Manzanillo olive trees during 2018 and 2019 seasons**

| Zinc sulphate | Boric acid | | | | Boric acid | | | |
|---|---|---|---|---|---|---|---|---|
| | 1.5 g/L | 3 g/L | 4.5 g/L | Mean | 1.5 g/L | 3 g/L | 4.5 g/L | Mean |
| | 2018 | | | | 2019 | | | |
| 2 g/L | 6.96 i | 7.19 f | 7.29 e | 7.09 C | 7.53 h | 7.94 e | 8.07 d | 7.84 C |
| 4 g/L | 7.05 h | 7.51 d | 7.68 c | 7.41 B | 7.63 g | 8.12 c | 8.17 b | 7.97 B |
| 6 g/L | 7.13 g | 7.88 b | 8.20 a | 7.79 A | 7.68 f | 8.21 b | 8.35 a | 8.08A |
| Mean | 7.10 C | 7.50 B | 7.69 A | | 7.61 C | 8.09 B | 8.19 A | |

Means within each column or row followed by the same letter (s) are not significantly at 5% level.

**Table 12. Effect of zinc sulphate and boric acid on initial fruit set (%) of Manzanillo olive trees during 2018 and 2019 seasons**

| Zinc sulphate | Boric acid | | | | Boric acid | | | |
|---|---|---|---|---|---|---|---|---|
| | 1.5 g/L | 3 g/L | 4.5 g/L | Mean | 1.5 g/L | 3 g/L | 4.5 g/L | Mean |
| | 2018 | | | | 2019 | | | |
| 2 g/L | 32.17 g | 33.32 fg | 34.31ef | 33.27C | 26.98 e | 28.13de | 29.12cd | 28.08C |
| 4 g/L | 35.54 de | 36.28 cd | 37.64 c | 36.48 B | 30.29 cd | 31.07 c | 32.98 b | 31.45B |
| 6 g/L | 39.65 b | 42.12 a | 42.61 a | 41.46 A | 34.75ab | 36.36 a | 36.41 a | 35.84A |
| Mean | 35.79 C | 37.24 B | 38.19A | | 30.67C | 31.85 B | 32.84 A | |

Means within each column or row followed by the same letter (s) are not significantly at 5% level.

**Subsequent fruit retention (%):**

Data presented in Table (13) shows from the first of June until to the first of October that the highest subsequent fruit retention (%) were recorded with 6 g/L zinc sulphate followed by zinc sulphate at 4 g/L and 2 g/L, respectively.

Furthermore, the highest subsequent fruit retention **(%)** were recorded with 4.5g/L followed by 3 g/L and 1.5 g/L concentration of boric acid in the two seasons.

The interaction effect of zinc sulphate and boric acid concentration proved that the highest increment subsequent fruit retention (%) were scored with zinc sulphate at 6 g/L or 4 g/L, plus boric acid at 4.5 g/L or 3 g/L, whilst the lowest values were recorded with zinc sulphate 2 g/L plus boric acid 1.5 g/L.

**Table 13. Effect of zinc sulphate and boric acid on subsequent fruit retention (%) of Manzanillo olive trees during 2018 and 2019 seasons**

| Zinc sulphate | Boric acid | | | | Boric acid | | | |
|---|---|---|---|---|---|---|---|---|
| | 1.5 g/L | 3 g/L | 4.5 g/L | Mean | 1.5 g/L | 3 g/L | 4.5 g/L | Mean |
| | 2018 | | | | 2019 | | | |
| | | | | June 1 | | | | |
| 2 g/L | 27.74 f | 29.39 e | 29.99 e | 29.04C | 24.67 e | 24.07 e | 22.42 f | 23.72C |
| 4 g/L | 30.86 de | 31.92 cd | 32.58bc | 31.78 B | 25.53de | 26.59cd | 27.25bc | 26.45B |
| 6 g/L | 32.96 bc | 33.91 ab | 34.61 a | 33.82A | 27.62bc | 28.57ab | 29.27 a | 28.48A |
| Mean | 30.52 C | 31.74 B | 32.39A | | 25.19C | 2641 B | 27.06 A | |
| | | | | July 1 | | | | |
| 2 g/L | 23.44 g | 24.30 fg | 24.95 f | 24.23C | 18.04 g | 18.90fg | 19.55 f | 18.83C |
| 4 g/L | 25.55 ef | 26.99 de | 28.01cd | 26.85 B | 20.13ef | 21.57de | 22.59cd | 21.43B |
| 6 g/L | 28.80 bc | 29.74 b | 31.58 a | 30.04A | 23.37bc | 24.31 b | 26.15 a | 24.61A |
| Mean | 26.93 C | 27.01 B | 28.18A | | 20.51C | 21.59 B | 22.76 A | |
| | | | | August 1 | | | | |
| 2 g/L | 2.35 f | 2.63 ef | 2.96 ef | 2.65 C | 1.80 f | 2.08 ef | 2.41 ef | 2.10 C |
| 4 g/L | 3.37 de | 4.07 d | 5.23 c | 4.22 B | 2.80 de | 3.50 d | 4.66 c | 3.65 B |
| 6 g/L | 5.99 bc | 6.70 ab | 7.07 a | 6.59 A | 5.40 bc | 6.11 ab | 6.48 a | 6.00 A |
| Mean | 3.90 C | 4.47 B | 5.09 A | | 3.33 C | 3.90 B | 4.52 A | |
| | | | | September 1 | | | | |
| 2 g/L | 1.02 f | 1.18 e | 1.42 d | 1.21 C | 0.60 f | 0.76 e | 1.00 d | 0.79 C |
| 4 g/L | 1.64 c | 1.77 b | 1.86 ab | 1.76 B | 1.17 c | 1.30 b | 1.39 ab | 1.9 2 B |
| 6 g/L | 1.94 a | 1.96 a | 1.99 a | 1.96 A | 1.43 ab | 1.45 ab | 1.48 a | 1.45 A |
| Mean | 1.53 C | 1.63 B | 1.76 A | | 1.07 C | 1.17 B | 1.29 A | |
| | | | | October 1 | | | | |
| 2 g/L | 1.02 f | 1.18 e | 1.42 d | 1.21 C | 0.60 f | 0.76 e | 1.00 d | 0.79 C |
| 4 g/L | 1.64 c | 1.77 b | 1.86 ab | 1.76 B | 1.17 c | 1.30 b | 1.39 ab | 1.9 2 B |
| 6 g/L | 1.94 a | 1.96 a | 1.99 a | 1.96 A | 1.43 ab | 1.45 ab | 1.48 a | 1.45 A |
| Mean | 1.53 C | 1.63 B | 1.76 A | | 1.07 C | 1.17 B | 1.29 A | |

Means within each column or row followed by the same letter (s) are not significantly at 5% level.

Concerning, the positive results of zinc sulphate concentrations in harmony with previous studies of reported by Usenik & Stampar (2002) and Ute & Clemens, 2005. Zinc lack effect on pollen production and pollen physiology may be it is closely involved in pollen tube growth resulted from its role on tryptophan synthesis as an auxin precursor biosynthesis according to Alloway 2004 and Hassan *et al.,* (2010) Sotomayor *et al.,* (2002) and Baybordi & Malakouti (2009) mentioned that zinc is related to fruit set, its role to flowering enhancement. Wojcik, 2007 found that foliar applications of Zn successes and promote the tree fruit set, in apple and Hafez and El-Metwally, 2007 in 'Washington Navel' orange.

These results are in harmony with those studies which used boric acid concentrations on flowering characteristics by Peres & Reyes (1983) who found that tree boron requirement is much higher for increases flower production and retention. Christensen *et al.* (2016) found that boron has been playing a more essential role in fertility, because it increase pollen germination in a number of tree species including almond (Nyomora *et al.,* 1997), pear (Lee *et al.,* 2009), fruit set in almond, sweet cherry and apple (Nyomora *et al.,* 1997; Shrestha *et al.,* 1987; Silva *et al.,* 2003; Usenik & Stampar, 2002 and Wojcik & Treder, 2006). May be boron deficiency reduced pollen production and poor fruit set and boron is required in stigma and styles to physiologically inactivate callus present in pollen tube walls (Lewis, 1980), Furthermore, Perica *et al.* (2001) mentioned that boric acid significantly enriched the developing olive flowers, boron application increases fruit set in nut crops (Perica *et al.,* 2001; Hanson, 1991 and Nyomora *et al.,* 1999). Boron foliar application increased fruit set in olive cultivars such as "Manzanillo" (Perica *et al.,* 2001), "Koronaiki" and "Boutilan" (Desouky *et al.,* 2009), navel oranges (Maurer and Taylor, 1999), pear "Conference" (Wojcik and Marzena 2003).

Also, these results are in agreement with Osman (1999) recorded boron treatments either as foliar or soil applications increased percentage of retained fruits on olive trees.

Motesharezade *et al.* (2001) and Bybordi & Malakout (2006) they showed that both zinc and boron have important role on pollination and fruit set. Saadati *et al.* (2016) mentioned that foliar application of zinc and/or boric acid significantly increased fruit set and Talaie *et al.* (2001) showed that foliar spray of B and Zn decreased fruit drop in the 'Zard' olive.

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## الملخص العربي

# تأثير الزنك والبورون على النمو الخضرى والاثمار لاشجار الزيتون صنف مانزانيللو تحت ظروف واحة سيوة

أسامة حلمى محمد الجمال

أجريت الدراسة خلال موسمي ٢٠١٨ و ٢٠١٩ على أشجارالزيتون صنف مانزانيلوا بواحة سيوة ، الأشجار منزعة على مسافة ٥ × ٥ متر في تربة رملية ، تحت نظام الري السطحي. تصميم التجربة قطع منشقة مرة واحدة وكل معاملة تضم ٣ مكررات ، كبريتات الزنك في القطع الرئيسية (٢ جم / لتر ، ٤ جم / لتر و ٦ جم / لتر) وحمض البوريك بالقطع الفرعية (١,٥ جم / لتر ، ٣ جم / لتر و ٤,٥ جم / لتر)، تم الرش الورقي بمعاملات كبريتات الزنك وحمض البوريك مرتين ، الأولى قبل الإزهار في نهاية فبراير والثانية في الأول من مايو لمقارنة تأثيرات الرش على النمو الخضري ،والازهار، والإثمار على أشجار الزيتون. أوضحت النتائج أن النمو الخضري، خصائص الورقة تتمثل فى (طول وعرض ومساحة الورقة)، والقياسات الزهرية (عدد النورات لكل فرع وعدد الازهار لكل نورة والنسبة المئوية للازهار التامة) وعقد الثمار (النسبة المئوية للعقد الاولى والنسبة المئوية للثميرات العاقدة)، سجلت أعلى القيم مع أعلى تركيز لكل من كبريتات الزنك وحمض البوريك فى كلا الموسمين، بالاضافة الى أعلى القيم للثمار المتبقية (٪) المسجلة من الأول من يونيو حتى الأول من أكتوبر سجلت مع كبريتات الزنك بتركيزات ٦ جم / لتر أو ٤ جم / لتر بالاضافة الى حمض البوريك بتركيزات ٤,٥ جم / لتر أو ٣ جم / لتر أعلى القيم، وأقل القيم تم تسجيلها مع كبريتات الزنك ٢ جم / لتر بالإضافة إلى حمض البوريك ١,٥ جم / لتر.

الكلمات المفتاحية: زيتون – مانزانيلو – الزنك – البورون – نمو خضرى – ازهار – الاثمار– سيوة.