Effect of Zinc and Boron on Yield and Fruit Quality of Manzanillo Olive Tree under Siwa Oasis Conditions

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ABSTRACT

This investigation was carried out on olive trees (*Olea europaea* L.) cv. Manzanillo grown in private orchard at Siwa Oasis located in Marsa Matruh (governorate) Egypt, during 2018 and 2019 seasons planted in sandy soil. The aim of this study was to investigate the effect of foliar sprays with zinc sulphate at 2, 4 and 6 g/L and boric acid 1.5, 3 and 4.5 g/L on yield, fruit quality and oil properties of Manzanillo olive trees.

Results showed that zinc sulphate and/or boric acid foliar sprays alone or in combination enhanced yield, fruit quality and oil properties of " Manzanillo " olive trees, In addition, zinc sulphate concentration at 6 g/L with boric acid concentrations at 4.5 g/L was the most effective treatment in improving yield, fruit weight, fruit volume, fruit length, fruit width, pulp thickness, fruit moisture content, oil extracted, lower oil acidity and proved to be saponification number.

Key word: Manzanillo - Olive - Zinc – Boron - Yield - Fruit Quality- Oil properties.

INTRODUCTION

Olea europaea L., in family Oleaceae, is one of the most important tree and a widely distributed and grown in many arid and semi-arid areas (Connos & Fereres, 2005 and Sofo *et al.,* 2008). Olives are considered among the major commercial fruit varieties grown in Egypt, it ranks the fourth after citrus, mango and grapes. Siwa Oasis is one of the most important areas of olive production. Olive yield is economic importance to Siwa Oasis. It is considered an appropriate region for olive production on a large scale (Hedia and Abd Elkawy, 2016). The Spanich cv. Manzanillo is early ripening cultivar and dual purpose can be used for pickling or oil extraction.

Zinc deficiency is visually expressed as small leaves, delayed opening of vegetative and flower buds, wrinkle or waving leaves with upward folded leaf margins and terminal dieback (Ramos, 1997). While, boron deficiency is quite common in olive trees (Poly, 1986 and Nyomora *et al.,* 1999), the deficiency is usually described as leaf-tip yellowing, shoot die back, fruit drop and break abnormalities, in addition to death of the terminal bud that results in a" bushy" appearance, are common symptoms of B deficiency (Perica *et al.,* 2001). However, the B deficiency on fruit is usually described as abnormal fruit development or "monkey face" (Perica *et al.,* 2001). Most the visually of zinc and boron deficiency symptoms are common in olive orchards that grown at Siwa Oasis. So, the olive trees suffering from Z and B deficiency and their foliar treatments are a must.

Zinc is required in small but critical concentration for the functioning of several plants physiological like photosynthesis, sugar formation, nucleic acid metabolism, protein and carbohydrate biosynthesis (Baghdady *et al.,* 2014 and Jerlin *et al.,* 2017). Zinc has an enzymatic and reactive function by involving in the catalytic function of the enzyme and zinc binding sites in a wide range of other proteins, membrane lipids and DNA (Klug, 1999 and Englbrecht *et al.,* 2004). Zn is directly involved in the catalytic function of the enzyme and zinc binding sites by means of engineering and binding properties (Auld, 2001 and Maret, 2005), zinc is a cofactor of over 300 enzymes and proteins and has an early and specific effect on cell division, nucleic acid metabolism, and protein synthesis (Marschner, 1986). Ramezani and Shekafandeh (2009) reported that zinc sulphate had positive effects on fruit characteristics such as fruit weight and fruit dimensions of 'Shengeh' olive cultivar. Also, Zn deficiency greatly affected the productivity of many deciduous fruit crops (Usenik & Stampar, 2002 and Krämer &. Clemens, 2005)

The main function of boron relate to cell wall strength and development, cell division, sugar transport and hormones development, RNA metabolism, respiration, indole acetic acid (IAA) metabolism and as part of the cell membranes (Camacho-Cristóbal *et al.,* 2008). The boron requirement is much higher for increases fruit development (Peres and Reyes, 1983). Boron application increases yield in several fruit and nut crops, such as almond, and sour cherry (Perica *et al.,* 2001; Hanson, 1991a and Nyomora, 1997), which significantly enriched the developing fruits (Perica *et al.,* 2001). Foliar applications of boron were effective in tree (Blevins et al., 1998 and Hu *et al.,* 1997) and it is a common practice in getting profitable yield and good quality fruit (El-Khawaga *et al.,* 2007a). Abd El-Migeed *et al.*(2002) reported that boric acid spray at 300 mgl^{-1} increased fruit length on 'Picual' olive. Khayyat *et al.* (2007) reported that boric acid at 1500 mgl^{-1} on

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'Shahany' date palm increased pulp weight, pulp/seed ratio; fruit length and diameter. Gul *et al.* (2017), when boron foliar sprayed at pre-bloom stage recorded maximum fruit yield per plant, whereas when applied at fruit set stage give the maximum single fruit weight, fruit size, flesh percentage and minimum fruit stone percentage. Furthermore, B treatment at 600 ppm increased the fruit yield plant, fruit weight, fruit size, fruit flesh, oil and minimum stone. Also, Maksoud *et al.*(2004) and Eassa (2006), they indicated that boron foliar application significantly increased yield of Manzanillo, Aggizi and Picual olive cultivars.

Zinc and boron have important to profitable yield and good quality fruit (Motesharezade *et al.,* 2001 and El-Khawaga 2007b). Talaie *et al.* (2001) showed that foliar spray of B and Zn increased fruit quality in the 'Zard' olive. And Saadati *et al.* (2016) found that foliar application of zinc and/or boric acid significantly improved fruit quality and zinc was more effective in quality characteristics such as increasing fruit length. Zinc and boron have important total yield (Motesharezade *et al.,* 2001).

Sourour *et al.* (2011), revealed that boric acid alone, or mixtured with chelated (Fe, Zn and Mn) and their combinations significantly increased yield and fruit quality (average fruit weight, fruit diameter, fruit length, pulp weight). Application mixture of (Fe + Zn + Mn) at 500 ppm + H_3BO_3 at 500 ppm was more effective than found with other treatments in both seasons. Moreover, Sayyad-amin *et al.* (2015), they obtained that zinc sulphate and boric at 2000 mg l^{-1} are effective on yield and fruit oil percentage. Amit *et al.* (2014) concluded that application of 5% zinc sulphate in combination with 0.5 boric acid proved to be the best for improving fruit size, weight and volume, pulp:stone ratio and oil content of olive cultivar Frontoio. Also, (Desouky *et al.,* 2009 and Ramezani *et al.,* 2010) reported that of zinc and boron application increased the olive yield and fruit quality. Further, there was a positive correlation between the fruit Zn concentration and oil content of olive fruits (Taheri and Talaie, 2001). Saadati *et al.*(2016), mentioned that the foliar application of zinc sulphate, boric acid and their combinations significantly promoted oil contents of olive fruits and enhanced both the quantity and quality of oil content such as oleic acid and phenolic compounds in olive fruits in semiarid areas.

This investigation was carried out to evaluate effect of foliar spraying with zinc sulphate at 2, 4 and 6 g/L and boric acid at 1.5, 3 and 4.5 g/L on yield and fruit quality of Manzanillo olive tree under Siwa conditions.

MATERIALS AND METHODS

1. Plant Selection:

This study was carried out during two successive seasons of 2018 and 2019 seasons in private orchard at Siwa Oasis located in Marsa Matruh (governorate), western Egypt on "Manzanillo" olive of eleven years old, grown in sandy soil, spaced 5x5m apart and subjected to surface irrigation. Soil analysis of experimental orchard and irrigation water were analyzed and presented in Tables (1, 2 and 3).

2. Experiment design.

The present study was designed as in a factorial experiment with two factors i.e. the first factor consists of 3 levels of zinc sulphate ($Zn_2SO_4.H_2O$ 36%) foliar spray of 2, 4 and 6 g/L and the second factor consist of 3 levels of boric acid ($H_2 BO_3$) 1.5, 3 and 4.5 g/L. Foliar application was done in early morning, treatments were performed by spraying 5 liter per tree of the Zn_2SO_4 and boric acid with a hand-pump knapsack sprayer, and Tween-20 was added at 0.1% as a surfactant to spray solution.

Foliar sprays of zinc sulphate and boric acid treatments were performed in 1st June.

3. Measurement and determination

3.1. Yield Kg/tree.

Fruits were harvested at the second week of October. Fruit harvesting was conducted manually, the yield weighted (Kg) and recorded.

3.2. Fruit quality

Samples of hundred healthy fruits were randomly taken from tree canopy to determine the following fruit quality parameters (fruit weight (g), fruit volume (cm^3), fruit length (cm) fruit width (cm), and pulp thickness (mm). Fruit moisture content was determined from 50g of olive fruits, hence they were dried in an oven at 80^{o}C till a constant weight. Fruit oil content was determined by extracting dry material (50 g) with 40- 60^o C petroleum ether using a Soxhlet apparatus.

3.3. Oil properties

Some parameters of oil quality such as oil acidity (Oleic acid) and Saponification number for oil extract were determined according to A.O.A.C (2000).

4. 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).

Table 1. Mechanical analysis of the experimental soil

Depth (cm)	Sand (%)	Silt (%)	Clay (%)	Soil texture
0-30	91.90	5.25	1.85	Sandy

Table 2. Chemical analysis of the experimental soil

pH	E.C	O.M.	Soluble anions (meq/l)				Soluble cations (meq/l)			
	(ds/m)	(%)	CO_3^{--}	HCO_3^-	Cl^-	SO_4^{--}	Ca^{++}	Mg^{++}	Na^+	K^+
7.8	1.4	0.5	-	6	31.3	6.1	8.6	7.5	0.20	24.7

Table 3. Chemical analysis of experimental ground water

pH	E.C	Soluble anions (meq/l)				Soluble cations (meq/l)			
	(ds/m)	CO_3^{--}	HCO_3^-	Cl^-	SO_4^{--}	Ca^{++}	Mg^{++}	Na^+	K^+
7.02	4.1	-	1.50	15.61	20.13	10.42	7.83	18.72	0.65

RESULT AND DISCUSSION

1. Tree yield (kg)/tree

Table (4) shows that zinc sulphate concentration at 6 g/L gave the highest yield (17.83 and 57.91 Kg/tree) per tree followed by descending 4 g/L concentration (17.72 and 57.07 Kg/tree), respectively. Moreover, 2 g/L has recorded the lowest tree yield (17.01 and 56.28 Kg/tree) in both seasons. Yield was significantly affected by zinc sulphate concentration. However, significant differences in tree yield were produced negatively by reducing zinc sulphate concentration.

Furthermore, boric acid concentrations at 4.5 g/L (17.74 and 57.91 Kg/tree) induced the highest tree yield followed by 3 g/L (17.71 and57.79 Kg/tree) and 1.5 g/L (16.76 and 55.56 Kg/tree) in both seasons.

In addition, zinc sulphate concentration at 6 g/L combined with boric acid concentrations at 4.5 g/L (18.33and 59.11) proved to be the most effective treatment in improving yield (Kg/tree). On the contrary, zinc sulphate concentration at 2 g/L combined with boric acid concentrations at 1.5 g/L (16.57 and 55.50 kg/tree) gave comparatively the lowest values in this respect.

2. Fruit quality:

2.1. Fruit weight (g)

Table (5) illustrates that 6 g/L of zinc sulphate concentration resulted in the highest fruit weight value followed descending by 4 g/L and 2 g/L zinc sulphate concentrations in both seasons.

Moreover, the highest fruit weight was recorded with boric acid 4.5 g/L followed by boric acid 3.0 g/L and boric acid 1.5 g/L, respectively in both seasons.

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

2.2. Fruit volume (cm^3)

Table (6) shows that zinc sulphate concentration at 6 g/L gave the highest fruit volume (7.31 and 6.07 cm^3) followed by 4 g/L zinc sulphate concentration (7.03 and 5.95 cm^3) in descending order. Meanwhile, the lowest fruit volume was recorded with 2 g/L zinc sulphate (6.97 and 5.87 cm^3) in both seasons.

Table 4. Effect of zinc sulphate and boric acid on yield (Kg) 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	16.57 i	17.20 f	17.62 e	17.01 C	55.50 i	56.65 f	56.69 e	56.28 C
4 g/L	16.75 h	17.42 d	17.65 c	17.27 B	55.56 h	57.70 d	57.95 c	57.07 B
6 g/L	16.96 g	18.22 b	18.33 a	17.83 A	55.62 g	59.02 b	59.11 a	57.91 A
Mean	16.76 C	17.71 B	17.74 A		55.56 C	57.79 B	57.91 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 fruit weight (g) 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	6.73 i	7.19 f	7.32 e	7.08 C	5.65 i	6.09 f	6.21 e	5.98 C
4 g/L	6.86 h	7.46 d	7.53 c	7.28 B	5.79 h	6.32 d	6.47 c	6.19 B
6 g/L	7.00 g	7.80 b	7.94 a	7.58 A	5.92 g	6.62 b	6.77 a	6.43 A
Mean	6.86 C	7.48 B	7.59 A		5.78 C	6.34 B	6.48 A	

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

Table 6. Effect of zinc sulphate and boric acid on fruit volume (cm^3) 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	6.89 g	7.01 e	7.02 e	6.97 C	5.76 h	5.91 e	5.96 d	5.87 C
4 g/L	6.90 g	7.05 d	7.16 c	7.03 B	5.81 g	5.99 c	6.06 b	5.95 B
6 g/L	6.93 f	7.49 b	7.53 a	7.31 A	5.85 f	6.17 a	6.19 a	6.07 A
Mean	6.90 C	7.18 B	7.23 A		5.80 C	6.02 B	6.07 A	

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

In addition, the highest fruit volume was recorded with 4.5 g/L boric acid (7.23 and 6.07 cm^3) followed by 3 g/L boric acid (7.18 and 56.02 cm^3) and boric acid 1.5 g/L (6.90 and 5.80 cm^3) which recorded the lowest values in this respect in the first and second seasons, respectively.

The combined effects of zinc sulphate with boric acid concentrations showed that 6 g/L concentration of zinc sulphate with boric acid 4.5 g/L concentration were the most effective treatments in increasing fruit volume (7.53 and 6.19 cm^3), followed finally by the corresponding ones of 2 g/L zinc sulphate combined with 1.5 g/L boric acid the less effective fruit volume (6.89 and 5.78 cm^3).

2.3. Fruit length (cm)

Table (7) indicates that zinc sulphate at 6 g/L recorded the highest fruit length value followed by zinc sulphate at 4 g/L and zinc sulphate at 2 g/L respectively in both seasons.

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

The interaction between zinc sulphate and boric acid concentrations reveals that the highest fruit length was recorded with 6 g/L zinc sulphate supported with 4.5 g/L boric acid concentrations.

2.4. Fruit width (cm)

It is clear from Table (8) that 6 g/L zinc sulphate concentration produced the widest fruits as compared with those given with 4g/L and 2 g/L zinc sulphate in both seasons. Furthermore, the highest fruit width value was recorded with 4.5 g/L boric acid followed by 3 g/L boric acid and boric acid 1.5 g/L which recorded the lowest values in both seasons, respectively.

The interaction between zinc sulphate and boric acid concentrations illustrates that the highest fruit width was recorded by high 6 g/L zinc sulphate provided with 4.5 g/L boric acid concentration.

Table 7. Effect of zinc sulphate and boric acid on fruit 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	2.24 f	2.30 d	2.30 d	2.28 C	2.47 d	2.49 bcd	2.49 bcd	2.48 B
4 g/L	2.26 ef	2.30 d	2.34 c	2.30 B	2.48 cd	2.50 bc	2.51 ab	2.49 B
6 g/L	2.28 de	2.37 b	2.41 a	2.35 A	2.48 cd	2.53 a	2.53 a	2.51 A
Mean	2.26 C	2.32 B	2.35 A		2.47 B	2.50 A	2.51 A	

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

Table 8. Effect of zinc sulphate and boric acid on fruit 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	2.26 e	2.27 de	2.28 de	2.27 C	2.15 e	2.16 de	2.14 e	2.15 C
4 g/L	2.26 e	2.29 cd	2.31 bc	2.28 B	2.15 e	2.18 cd	2.19 bc	2.17 B
6 g/L	2.26 e	2.32 b	2.35 a	2.31 A	2.16 de	2.21 ab	2.23 a	2.20 A
Mean	2.26 C	2.29 B	2.31 A		2.15 B	2.18 A	2.18 A	

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

2.5. Pulp thickness (mm).

Result in table (9) represented a slight differences were noticed among the three applied zinc sulphate treatments on pulp thickness in both seasons. The higher zinc Sulphate treatment significantly increased pulp thickness as compared with lest zinc treatment in the first season only. Meanwhile, no significant differences were in the second season.

Furthermore, pulp thickness was no significant affected from 4.5 g/L boric acid to 3 g/L boric acid concentration. The highest pulp thickness values were recorded with 4.5 g/L boric acid concentration followed by 3 g/L boric acid concentration and 1.5 g/L boric acid concentration in both season.

The interaction effect of zinc sulphate and boric acid proved that the highest pulp thickness values were found with zinc sulphate at 6 g/L plus 4.5 g/L boric acid concentration, whilst the lowest values were found with zinc sulphate at 2 g/L with 1.5 g/L boric acid concentration.

2.6. Fruit moisture (%)

Table (10) demonstrates that increasing zinc sulphate concentrations from 2 g/L to 4 g/L and 6 g/L caused a steady increase in fruit moisture content in the first and the second seasons.

Furthermore, it is clear that 4.5 g/L boric acid concentration recorded the highest fruit moisture followed by 3 g/L boric acid concentration and 1.5 g/L boric acid concentration in both seasons.

Moreover, the interaction between zinc sulphate and boric acid showed that 6 g/L zinc sulphate supplemented with 4.5 g/L boric acid concentration scored the highest values of fruit moisture content, while the lowest value was recorded with the combination of 2 g/L zinc sulphate and 1.5 g/L boric acid concentration.

Table 9. Effect of zinc sulphate and boric acid on pulp thickness (mm) 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	0.88 e	0.90 cde	0.91 bcd	0.89 B	0.78 c	0.80 abc	0.80 abc	0.79 A
4 g/L	0.89 de	0.91 bcd	0.92 abc	0.90 B	0.79bc	0.80 abc	0.80 abc	0.79 A
6 g/L	0.90 cde	0.93 ab	0.94 a	0.92 A	0.79 bc	0.81 ab	0.82 a	0.80 A
Mean	0.89 B	0.91 A	0.92 A		0.78 B	0.80 A	0.80 A	

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

Table 10. Effect of zinc sulphate and boric acid on fruit moisture (%) 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	51.31 i	52.74 f	53.85 e	52.63 C	51.21 i	51.45 f	51.48 e	51.38 C
4 g/L	51.43 h	54.16 d	55.00 c	53.53 B	51.24 h	51.78 d	52.37 c	51.79 B
6 g/L	51.60 g	55.31 b	56.37 a	54.42 A	51.29 g	53.48 b	54.47 a	53.08 A
Mean	51.4 4C	54.07 B	55.07 A		51.24 C	52.23 B	52.77 A	

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

2.7. Fruit oil percentage (%).

Table (11) illustrates that zinc sulphate at 6 g/L gave the highest fruit oil content followed by zinc sulphate at 4 g/L and zinc sulphate at 2 g/L.

Furthermore, the highest oil percentage value was recorded with 4.5 g/L boric acid followed by 3 g/L boric acid and 1.5 g/L boric acid concentrations. In addition, zinc sulphate at 6 g/L combined with 4.5 g/L boric acid concentration proved to be the most effective concentration in improving fruit oil percentage. On the contrary, zinc sulphate at 2 g/L combined with 1.5 g/L boric acid concentration gave comparatively the lowest values in this respect.

3. Oil properties

3.1. Oil acidity

Table (12) indicates that 2 g/L zinc sulphate concentration gave highest oil acidity followed by descending 4 g/L zinc sulphate concentrations, respectively. Furthermore, 6 g/L zinc sulphate has recorded the lowest oil acidity in both seasons. While, no significant difference was noticed between 2 g/L and 4 g/L, also no significant difference between 4 g/L and 6 g/L concentrations of zinc sulphate in first season. Moreover, no significant difference was noticed between 6 g/L and 4 g/L concentrations in the second season.

Regarding to boric acid treatments with 1.5 and 3 g/L recorded higher significant olive oil acidity as compared with treated with 4.5 g/Lin both seasons. No significant differences were noticed among 1.5 and 3 g/L boric acid treatments in 2018 and 2019.

Furthermore, 2 g/L zinc sulphate plus 1.5 g/L boric acid proved to be the most effective combination in this respect in the first season.

3.2. Oil saponification number

Table (13) shows that saponification number was significantly affected by zinc sulphate and boric acid treatments. 6 g/L zinc sulphate gave the highest saponification number followed by 4 g/L zinc sulphate and 2 g/L zinc sulphate.

Concerning boric acid concentrations the highest saponification number was recorded with 4.5 g/L boric acid followed by 3 g/L boric acid and 1.5 g/L boric acid treatments which recorded the lowest values in both seasons.

Moreover 6 g/L zinc sulphate with 4.5 g/L boric acid concentrations proved to be the most effective interaction in increasing saponification number. On the contrary, 2g/L zinc sulphate provided with 1.5 g/L boric acid concentrations gave comparatively the lowest value in this concern.

The obtained results regarding the effect of zinc sulphate on yield and fruit quality go on line with the finding by Usenik & Stampar (2002) and Krämer & Clemens (2005) indicated that Zn deficiency effect on yield and Ramezani & Shekafandeh (2009) reported that zinc sulphate had positive effects on fruit characteristics such as fruit weight and fruit dimensions of ‘Shengeh’olive cultivar.

Table 11. Effect of zinc sulphate and boric acid on oil percentage (%) 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	35.51 i	38.28 f	38.34 e	37.37 C	34.71 i	37.16f	37.22 e	36.36 C
4 g/L	36.85 h	38.45 d	38.78 c	38.02 B	35.42 h	37.43 d	37.59 c	36.81 B
6 g/Ls	37.93 g	39.54 b	39.66 a	39.04 A	36.83 g	38.35 b	38.53 a	37.90 A
Mean	36.76 C	38.75 B	38.92 A		35.65 C	37.64 B	37.78 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 oil acidity 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	0.88 bcd	0.90 ab	0.85 e	0.89 A	0.88 bc	0.91 a	0.85 d	0.89 A
4 g/L	0.90 ab	0.89 abc	0.86 de	0.88 AB	0.89 ab	0.89 ab	0.86 cd	0.88 B
6 g/L	0.91 a	0.88 bcd	0.87 cde	0.87 B	0.91 a	0.87 cd	0.87 bcd	0.86 B
Mean	0.89 A	0.89 A	0.86 B		0.89 A	0.89 A	0.86 B	

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

Table 13. Effect of zinc sulphate and boric acid on oil saponification number 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	217.86 i	220.63 f	220.69 e	219.73 C	217.06 i	219.51 f	219.57 e	218.71C
4 g/L	219.20 h	220.80 d	221.13 c	220.38 B	217.77 h	219.78 d	219.94 c	219.16B
6 g/L	220.28 g	221.89 b	222.01 a	221.39 A	219.18 g	220.70 b	220.88 a	220.25A
Mean	219.11 C	221.11 B	221.28 A		218.00 C	220.00 B	220.13 A	

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

These results go in line with those obtained by Perica et al. (2001); Hanson (1991b); Nyomora *et al.* (1997) and El-Sheikh *et al. (*2007) whose found that boron application increases yield in several fruit Moreover, Perica *et al.* (2001), indicated that which significantly enriched the developing fruits. Also, Blevins *et al.* (1998) and Hu *et al.* (1997), foliar applications of boron were effective in tree and nut crops, such as almond, and sour cherry and El-Khawaga *et al.* (2007a) conducted that boron is a common practice in getting profitable yield of Manzanillo olive trees. Gul *et al.* (2017) maintain that boron concentrations at 600 ppm increasing on fruit yield.

Also, Maksoud *et al.* (2004) and Eassa (2006) they indicated that boron foliar application significantly increased yield of Manzanillo, Aggizi and Picual olive cultivars. And Sourour *et al.* (2011) revealed that boric acid alone, or mixture chelated (Fe, Zn and Mn) and their combinations significantly increased yield of olive tree. Perica *et al.* (2001) found that boron is significantly enriched the developing fruits, Abd El-Migeed *et al.* (2002) mentioned that boric acid spray at 300 mgl^{-1} increased fruit length on 'Picual' olive. Khayyat *et al.* (2007) showed that boric acid at 1500 mgl^{-1} on 'Shahany' date palm increased pulp weight, pulp/seed ratio; fruit length and diameter.

Concerning, the positive results of zinc sulphate and boric acid treatments that performed in 1st June in harmony with previous studies of zinc sulphate levels and boric acid reported by Motesharezade *et al.* (2001) on sweet cherry and El-Khawaga (2007b) on pomegranate whose found that zinc and boron have important to profitable good quality fruit. Talaie *et al.* (2001) showed that foliar spray of B and Zn increased fruit quality in the 'Zard' olive, and Saadati *et al.* (2016) found that foliar application of zinc and/or boric acid significantly improved fruit quality and zinc was more effective in quality characteristics such as increasing fruit length of olive trees. Motesharezade *et al.* (2001) found that zinc and boron have important total yield.

The increase in productivity, improvement of fruit characters and oil quality might be due to function of zinc in several plants physiological like photosynthesis, sugar formation, nucleic acid metabolism, protein and carbohydrate biosynthesis (Baghdady *et al.*, 2014 and Jerlin *et al.*, 2017). Zinc is binding sites in a wide range of other proteins, membrane lipids and DNA (Klug, 1999 and Englbrecht *et al.*, 2004) and Zn is directly involved in the catalytic function of the enzyme and zinc binding sites by means of engineering and binding properties (Auld, 2001 and Maret, 2005). In addition the main function of boron relate to cell wall strength and development, cell division, sugar transport and hormones development, RNA metabolism, respiration, indole acetic acid (IAA) metabolism and as part of the cell membranes (Camacho-Cristóbal *et al.*, 2008). Also the boron requirement is much higher for increases fruit development (Perez and Reyes, 1983). Rodrigues *et al.* (2011) found that the application of boron every year prevent reduction in tree crop performance and improve nutrient use efficiency.

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الملخص العربي

تأثير الزنك والبورون على المحصول وجودة ثمار أشجارالزيتون صنف مانزانيللو تحت ظروف واحة سيوة

أسامة حلمى محمد الجمال

تم إجراء هذا البحث على أشجار الزيتون صنف مانزانيلو. نامية في بستان خاص بواحة سيوة بمحافظة مرسى مطروح – مصر، خلال عامي ٢٠١٨ و٢٠١٩. لدراسة تأثير الرش الورقي بكبريتات الزنك بمعدل ٢ و٤ و٦ جرام لكل لتر وحمض البوريك ١,٥ و٣ و٤,٥ جرام لكل لتر. على المحصول وجودة الثمار وخصائص الزيت لأشجار الزيتون المانزانيلو.

أظهرت النتائج أن الرش الورقى بكبريتات الزنك وحامض البوريك كل منهما منفردا أو فى مخاليط تأثيرا ايجابيا على المحصول وجودة الثمار وكذلك خصائص الزيت لأشجار الزيتون المانزانيلو، بالإضافة إلى ذلك، ثبت أن كبريتات الزنك بتركيز ٦ جرام لكل لتر مع حمض البوريك بتركير ٤,٥ جرام لكل لتر هى المعاملة الأكثر فاعلية في تحسين المحصول ووزن وحجم الثمار طول وعرض الثمرة وسمك اللب ومحتوى الرطوبة بالثمار ونسبة الزيت وكذلك أقل حموضة للزيت وأعلى قيمة لرقم التصبن.

الكلمات المفتاحية: زيتون– مانزانيلو–الزنك– البورون – المحصول – جودة الثمار – خواص الزيت.