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Effect of Boron Foliar Application on Olive (*Olea europea* L.) Trees 1- Vegetative Growth, Flowering, Fruit Set, Yield and Fruit Quality

[1]*E.S. Hegazi,* [2]*R.A. El-Motaium,* [1]*T.A. Yehia and* [2]*M.E. Hashim*

[1]Department of Pomology, Faculty of Agriculture, Cairo University, Egypt
[2]Department of Plant Research, Nuclear Research Center, Inshas, Egypt

Abstract: This investigation was undertaken to study the effect of time and concentration of boron foliar application on olive trees (cv. Frantoio) vegetative growth, flowering, fruit set, yield and fruit quality. Treatments included six boron foliar sprays as boric acid prior to flowering at the following concentrations: 0.00, 100, 200, 300, 400, 500 mg.L^{-1}, applied on November, December and January during two successive seasons 2010/2011 and 2011/2012. The obtained results indicated that boron application significantly improved vegetative growth, flowering, fruit set, fruit yield and fruit quality compared with the control. The increase in fruit set was not accompanied by a reduction in fruit size. The highest increment of all mentioned traits was achieved at boron application rate of 200 mg.L^{-1} applied in January. Thus, this rate and time of boron application can be recommended for commercial use under similar condition.

Key words: Olive (*Olea europea* L.) · Boron · Vegetative growth · Flowering · Fruit set · Yield and fruit quality

INTRODUCTION

Olive (*Olea europea* L.) is considered one of the most important fruit crops in Egypt, which cultivated in a total area of 240,458 feddan with a total production of 541,790 ton/year [1].

Most of the olive trees in Egypt are planted in new reclaimed areas; the majority of these areas are sandy soil that lacked of macro and micro-nutrients. In addition, the Nile water used for irrigation lacks such nutrients. The low boron content in Nile water can contribute to low boron availability in sandy soil [2]. Boron deficiency is one of the most frequent micro-nutrient disorders in olive orchards [3]. As a consequence olive production in these areas is low.

Boron is an essential micro-nutrient required for flower fertility, fruit set and yield of olive [4]. Its deficiency exists more than any other micronutrient [5]. Boron deficiency resulted in low pollen viability, poor pollen germination and reduce pollen tube growth [6]. In addition, boron deficiency reduces crop yield due to reduction in perfect flowers. In olive, boron deficiency symptoms were observed when B concentration fell below 15 mg.kg^{-1} dry matter [7]. While the sufficient boron range in olive leaves was estimated to be 20-75 mg.kg^{-1} [8].

Foliar application of micronutrients (Zn, B) is more effective and economic than soil application to supply nutrients to plant directly and quickly [9]. Perica *et al.* [10] found that in olive cv. Manzanillo foliar boron application up to 491 mg.L-1, during flower initiation, increased the percentage of perfect flowers. It also increased fruit set by 43-54% in response to all boron application rates (0.0, 246, 491, 737 mg.L^{-1}). Spinardi and Bassi [11] reported that the response of fruit set of olive tree to boron foliar application differ among cultivars.

Therefore, this study was undertaken to determine the optimum time and concentration of boron foliar application that could lead to an increase in olive tree vegetative growth, flowering, fruit set, yield and fruit quality. This is in particular for olive trees grown in sandy soil and irrigated with the Nile water.

Corresponding Author: E.S. Hegazi, Department of Pomology, Faculty of Agriculture, Cairo University, Egypt.

MATERIALS AND METHODS

This study was conducted during two successive seasons 2010/2011 and 2011/2012 on twenty years old bearing olive (*Olea europaea* L.) trees cv. Frantoio¨, oil variety. Trees were grown at the Nuclear Research Center Experimental Farm, Inshas, El-Qaliubiya Governorate, Egypt. Trees were planted 5x5 meter apart in sandy soil under drip irrigation system using the Nile water. The trees received the recommended fertilizer rates (N, P, K). The leaf boron analysis was 13.4 $mg.kg^{-1}$.

Treatments: Trees were exposed to boron foliar application as boric acid (H_3BO_3). Boron was applied at six concentrations as follows: 0.00 'control', 100, 200, 300, 400, 500 $mg.L^{-1}$. Boron was applied prior to flowering at three dates: 1^{st} November, 1^{st} December and 1^{st} January during 2010/2011 and 2011/2012 seasons.

Measurement Parameters: Each treatment was represented by three replicates which were chosen at random, each tree was divided into four sides (South – West – North and East). Five of one year old shoots were chosen on each side and labeled for further measurements.

Specific Leaf Dry Weight S.L.D.W. ($mg.cm^2$): On September, twenty leaves/tree were chosen from one year old shoots. Leaves were positioned at 4^{th} -8^{th} from the top.

Leaf area was determined according to Ahmad and Morsey [12] using the following equation Leaf area = 0.53 (L x W) + 1.66 L= Length W= Width

Leaf dry weight was determined in the same leaves by oven drying at 70°C for 48 hours until a constant weight is reached.

SLDW= Leaf dry weight (g) x 1000/Leaf area (cm^2)

Perfect Flower Density: Number of perfect flowers/meter= No. of perfect flowers/ Shoot length according to Hegazi and stino [13].

Fruit Set: Fruit set was counted twice; the first time after 21days from full bloom (initial fruit set) and the second time after 60 days from full bloom (final fruit set) according to Hegazi and Hegazi, [14]. Percentage of fruit set was calculated using the following equation.

Initial or final fruit set % = No. of fruits / No. of perfect flowers x 100

Fruit Yield: Fruits were collected at ripening stage on mid-October of 2011 and 2012 years. Each individual tree was harvested manually and weight of fruits/tree for all trees was measured. Average yield /tree was calculated for each treatment.

Fruit Quality: Determination of fruit quality included the following characteristics: fruit weight (g), fruit size (cm^3), stone weight (g), flesh weight (g), percentage of flesh, fruit oil percentage and total oil yield (kg/tree).

Flesh weight (g) = Fruit weight – Stone weight
Percentage of flesh = flesh weight\fruit weight X 100

Oil percentage was determined in the fruit flesh on a dry weight basis using Soxhlet oil extraction apparatus with Hexane 60-80°C boiling point, according to Hegazi [15].

Experimental Design and Statistical Analysis: This work was conducted in 6×3 factorial experiment. The two factors are 6 boron concentration and 3 application times. Treatments were arranged in a Completely Randomized Block Design with three replicates for each treatment. The statistical analysis of the data was performed using Mstat [16] statistical program. The data was analyzed by ANOVA to determine the significance of the treatments and the least significant difference (LSD) was used for treatment means comparisons at p = 0.05 according to Snedecor and Cochran [17]. Linear regression and correlation was performed using Sigma plot program.

RESULTS AND DISCUSSION

Specific Leaf Dry Weight: Table (1) shows that the specific leaf dry weight significantly increased in response to boron foliar application in both seasons. The increase continued up to 200 mgL^{-1} boron rate followed by a reduction at the higher boron doses (300,400 and 500 $mg.L^{-1}$). However, at the higher doses the specific leaf dry weight values were still significantly higher than the control.

The highest specific leaf dry weight was recorded at 200 $mg.L^{-1}$ boron rate. There are no significant differences in specific leaf dry weight between the three times of boron application.

Table 1: Effect of boron spray on specific leaf dry weight (mg.cm^2) in 2010/2011 and 2011/2012 seasons

Specific leaf dry weight (mg.cm^2)							
	Boron Conc. (mg.L^{-1})						
Time	0.00	100	200	300	400	500	Mean (A)
			2010 - 2011 season				
Nov.	23.29	25.41	26.07	25.30	25.12	25.09	25.05
Dec.	23.23	25.45	26.06	25.37	25.24	25.14	25.08
Jan.	23.69	25.46	26.07	25.35	25.33	25.14	25.17
Mean (B)	23.40	25.44	26.07	25.34	25.23	25.12	
			2011 - 2012 season				
Nov.	22.70	24.29	25.00	24.23	24.03	23.91	24.03
Dec.	22.79	24.62	25.29	24.46	24.22	23.99	24.23
Jan.	22.63	24.75	25.51	24.62	24.31	24.26	24.35
Mean (B)	22.71	24.55	25.26	24.44	24.19	24.05	

LSD 0.05 2010 – 2011 season: A. N.S B. 0.380 A×B. 0.657

LSD 0.05 2011 – 2012 season: A. N.S B. 0.445 A×B. 0.771

Table 2: Effect of boron spray on the perfect flower density/meter in 2010/2011 and 2011/2012 seasons.

Perfect flower/meter							
	Boron Conc. (mg.L^{-1})						
Time	0.00	100	200	300	400	500	Mean (A)
			2010 - 2011 season				
Nov.	77.04	122.2	143.4	114.5	107.3	101.9	111.1
Dec.	78.66	133.4	145.3	133.3	115.0	107.1	118.8
Jan.	80.58	147.8	159.0	151.1	137.2	127.2	133.8
Mean (B)	78.76	134.5	149.2	133.0	119.8	112.1	
			2011 - 2012 season				
Nov.	65.97	105.3	112.8	101.6	96.06	90.79	95.41
Dec.	69.33	113.2	124.1	124.5	107.6	106.1	107.5
Jan.	72.06	131.9	138.1	133.1	126.0	120.7	120.3
Mean (B)	69.12	116.8	125.0	119.7	109.9	105.9	

LSD 0.05 2010 – 2011 season: A. 0.869 B. 1.229 A×B. 2.128

LSD 0.05 2011 – 2012 season: A. 0.964 B. 1.364 A×B. 2.362

Table 3: Effect of boron spray on the initial and final fruit set percentage in 2010/2011 and 2011/2012 seasons.

	Initial fruit set %							Final fruit set %						
							Boron Conc. (mg.L^{-1})							
Time	0.00	100	200	300	400	500	Mean (A)	0.00	100	200	300	400	500	Mean (A)
							2010 - 2011 season							
Nov.	5.814	7.961	8.114	8.150	7.032	6.638	7.285	3.032	5.885	6.611	6.424	5.367	4.494	5.302
Dec.	5.480	8.285	9.178	8.381	7.402	7.135	7.643	3.104	6.367	7.405	6.479	5.368	4.817	5.590
Jan.	5.287	8.475	9.967	9.381	8.450	7.691	8.208	3.011	6.437	8.158	7.412	5.733	5.400	6.025
Mean (B)	5.527	8.240	9.086	8.637	7.628	7.155		3.049	6.230	7.391	6.772	5.489	4.904	
							2011 - 2012 season							
Nov.	4.993	7.370	8.081	7.800	6.091	5.726	6.677	2.933	5.440	6.330	5.676	4.770	4.098	4.874
Dec.	4.630	7.874	8.755	8.112	6.781	6.701	7.142	2.901	5.813	6.868	6.162	5.184	4.526	5.242
Jan.	5.055	8.060	9.095	8.384	7.635	7.084	7.552	2.965	5.967	7.276	6.444	5.548	4.952	5.525
Mean (B)	4.892	7.767	8.643	8.099	6.836	6.503		2.933	5.740	6.824	6.094	5.167	4.526	

	2010 - 2011 season			2011 - 2012 season		
LSD 0.05 Initial fruit set	A. 0.093	B. 0.132	A× B. 0.229	A. 0.086	B. 0.121	A× B. 0.210
LSD 0.05 Final fruit set	A. 0.048	B.0.068	A× B. 0.117	A. 0.043	B. 0.061	A× B. 0.105

Perfect Flower Density: Table (2) shows that during the two seasons of this study the numbers of perfect flowers/meter was significantly higher than the control at all boron application rates.

The lower boron doses (100, 200 mg.L^{-1}) were more effective in increasing the number of perfect flowers than the higher ones (300, 400, 500 mg.L^{-1}). However, at the higher boron doses, number of perfect flowers was still higher than the control. Boron applied in January recorded significant increase in the number of perfect flowers compared with November or December application times.

The highest number of perfect flowers/meter was recorded at 200 mg.L^{-1} boron application rate. When boron applied at 200 mg.L^{-1} in January it increased the number of perfect flowers by 189% and 181% in heavy and light bearing year, respectively.

Fruit Set: Table (3) show that the initial and final fruit set percentages were increased in response to boron foliar application compared with the control. This increase proves to be true for the two years of this study.

The best boron treatment was 200 mg.L^{-1}, as it recorded the highest fruit set percentage. There was a reduction in fruit set percentage at higher boron rates (300, 400, 500 mg.L^{-1}) compared with the lower rates, but these values were still higher than the control. It is obvious that when leaf B concentration increased fruit set decreased.

The increase in the initial fruit set at 200 mg.L^{-1} boron application rate ranged from 140% to 189% in the heavy bearing year and from 162% to 189% in the light bearing year, relative to the control. The results are in the same line with Perica *et al.* [10] who found that boron foliar application resulted in significant increase in fruit set and yield, also the response was more pronounced when fruit set was low than when it was high.

Final fruit set was increased by 242% and 233% in heavy and light bearing year, respectively, when boron was applied at 200 mg.L^{-1} rate in January. Whereas, at higher dose (500 mg.L^{-1}), fruit set were increased by 161% and 154% in heavy and light bearing years, respectively. It is obvious that the percentage of fruit set was decreased at higher boron dose. This agrees with Spinardi and Bassi [11] who found that percentage of fruit set in olive cv. Frantoio was decreased from 211% to 134% with 262 and 525 mg.L^{-1} boron rate, respectively.

There were significant differences between the times of boron application on fruit set percentage. Boron applied in January caused a significant increase in fruit set percent comparing with November or December application time.

The obtained results agree with Nyomora *et al.* [18] who found that boron application at 245 or 490 mg.L^{-1} significantly increased fruit set and yield in almond and with Talai and Taheri [19] who found that B foliar application decreased the level of fruit abscission. The results also agree with Spinardi and Bassi [11] who found that B treatment increased fruit set significantly in Frantoio cultivar. However, Kilby *et al.* [20] reported that there was no increase in fruit retention of foliar B-treated pecan.

Fruit Yield: Results in Table (4) show a significant increase in olive fruit yield in response to boron foliar application comparing with the control. The lower boron doses (100, 200, 300 mg.L^{-1}) were more effective in increasing yield than the higher doses (400 and 500 mg.L^{-1}). The highest yield was recorded at 200 mg.L^{-1} of boron application rate. At this rate the yield was more than double of the control yield. The time of boron application shows that January application date was significantly higher than November or December. In the first season, olive fruit yield was increased by 244% with 200 mg.L^{-1} boron rate applied in January. However, the higher boron concentrations (400, 500 mg.L^{-1}) increased yield by only 178%. This could be due to boron toxicity to pollen grain at higher application rate [21].

In the second season, olive fruit yield was increased by 298% with 200 mg.L^{-1} boron rate applied in January. However, boron application rates of 400 and 500 mg.L^{-1} increased the yield by 224% and 211%, respectively.

The increase was more pronounced in light bearing year than in the heavy one. The concentration of boron that resulted in additional yield was similar (200-400 mg.L^{-1}) in all previous studies Perica *et al*. [10] and our results support this finding.

The effect of boron on yield could be due to an increase of photosynthetic capacity and/or increase in percent of perfect flowers. The increase in fruit yield may be due to the effect of boron on increase fruit set via increase pollen viability or pollen tube growth [22]. However, the mechanism of the effect of boron foliar application on yield is poorly understood [10].

Figures (1, 2) illustrate a highly significant and positive correlation between leaf area and yield, indicating an indirect involvement of boron in increasing yield. This could be due to the role of boron in cell division and elongation which lead to higher leaf area, higher photosynthetic area and more yield [23].

Fruit Quality: Fruit quality is assessed as fruit weight, fruit flesh weight, fruit size, stone weight and oil percent.

Fruit Weight: Results in Table (5) show significant increase in olive fruit weight in response to all rates of boron foliar application comparing with the control.

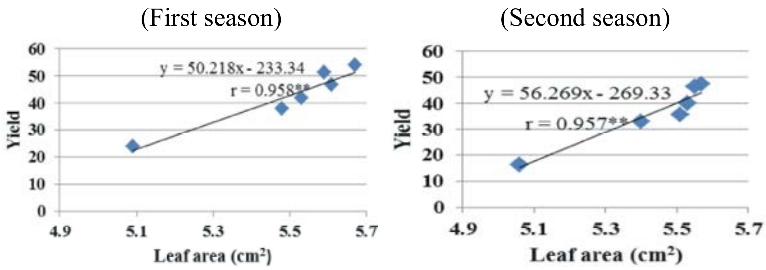

Fig. (1, 2): Linear correlation between olive fruit yield and leaf area

Table 4: Effect of boron spray on fruit yield (Kg\tree) in season 2010/2011 and 2011/2012 seasons

Total yield (kg\tree)							
Boron Conc. (mg.L^{-1})							
Time	0.00	100	200	300	400	500	Mean (A)
2010 - 2011 season							
Nov.	24.50	45.50	52.00	50.67	42.50	35.17	41.72
Dec.	23.83	47.17	53.50	50.67	42.17	37.67	42.50
Jan.	23.00	47.83	56.17	52.83	41.00	40.83	43.61
Mean (B)	23.78	46.83	53.89	51.39	41.89	37.89	
2011 - 2012 season							
Nov.	16.83	38.67	46.33	45.67	36.00	31.33	35.81
Dec.	16.17	40.00	47.33	46.17	34.67	33.33	36.28
Jan.	16.36	41.83	48.83	47.83	36.67	34.50	37.67
Mean (B)	16.45	40.17	47.50	46.56	35.78	33.06	

LSD 0.05 2010 – 2011 season: A. 1.209 B. 1.709 A×B. 2.961

LSD 0.05 2011 – 2012 season: A. 0.900 B. 1.267 A×B. 2.194

Table 5: Effect of boron spray on fruit weight (gm) in 2010/2011 and 2011/2012 seasons

Fruit weight (gm)							
Boron Conc. (mg.L^{-1})							
Time	0.00	100	200	300	400	500	Mean (A)
2010 - 2011 season							
Nov.	3.705	4.321	4.466	4.270	4.324	4.214	4.217
Dec.	3.590	4.296	4.566	4.334	4.340	4.307	4.239
Jan.	3.565	4.401	4.655	4.424	4.399	4.282	4.288
Mean (B)	3.620	4.340	4.562	4.343	4.354	4.268	
2011 - 2012 season							
Nov.	3.455	4.107	4.293	4.116	4.156	3.998	4.021
Dec.	3.357	4.071	4.415	4.185	4.206	4.118	4.059
Jan.	3.387	4.207	4.428	4.247	4.260	4.082	4.102
Mean (B)	3.400	4.128	4.379	4.183	4.207	4.066	

LSD 0.05 2010 – 2011 season: A. 0.061 B. 0.086 A×B. 0.148

LSD 0.05 2011 – 2012 season: A. 0.057 B. 0.080 A×B. 0.139

The maximum increase in fruit weight was recorded with 200 mg.L^{-1} boron rate. Fruit weight was higher when boron was applied on January than when applied on November or December.

Fruit Flesh Weight and Flesh Weight Percentage: Results in Table (6) show significant a increase in olive fruit flesh weight in response to boron foliar application comparing with the control.

Table 6: Effect of boron spray on fruit flesh weight (gm) and flesh weight percentage in 2010/2011 and 2011/2012 seasons

	Flesh weight (gm)							Flesh weight %						
	Boron Conc. (mg.L^{-1})													
Time	0.00	100	200	300	400	500	Mean	0.00	100	200	300	400	500	Mean (A)
	2010 - 2011 season													
Nov.	2.930	3.619	3.769	3.566	3.544	3.356	3.464	79.10	83.80	84.42	83.53	81.98	79.64	82.08
Dec.	2.801	3.482	3.875	3.553	3.489	3.454	3.442	78.13	81.06	84.90	82.00	80.39	80.21	81.11
Jan.	2.785	3.782	3.939	3.669	3.498	3.406	3.513	78.17	85.93	84.66	82.92	79.51	79.55	81.79
Mean (B)	2.839	3.628	3.861	3.596	3.510	3.405		78.47	83.59	84.66	82.82	80.62	79.80	
	2011 - 2012 season													
Nov.	2.699	3.550	3.709	3.449	3.404	3.291	3.350	78.10	86.46	86.39	83.80	81.91	82.35	83.17
Dec.	2.716	3.462	3.835	3.545	3.474	3.385	3.403	80.89	85.02	86.87	84.71	82.60	82.20	83.72
Jan.	2.763	3.771	3.874	3.622	3.490	3.387	3.484	80.50	88.59	86.46	84.22	80.87	82.03	83.78
Mean (B)	2.726	3.594	3.806	3.539	3.456	3.355		79.83	86.69	86.58	84.25	81.79	82.20	

	2010 - 2011 season			2011 – 2012 season		
LSD 0.05 Flesh weight (gm):	A. 0.057	B. 0.081	A× B. 0.139	A. 0.048	B. 0.068	A× B. 0.117
LSD 0.05 Flesh weight (%):	A. N.S	B.1.302	A× B. 2.256	A. N.S	B.1.078	A× B. 1.867

Table 7: Effect of boron spray on fruit size (cm^3) in 2010/2011 and 2011/2012 seasons

	Fruit size (cm^3)						
	Boron Conc. (mg.L^{-1})						
Time	0.00	100	200	300	400	500	Mean (A)
	2010 - 2011 season						
Nov.	3.548	4.262	4.435	4.248	4.253	4.183	4.155
Dec.	3.566	4.347	4.608	4.348	4.331	4.275	4.246
Jan.	3.783	4.469	4.748	4.392	4.355	4.262	4.335
Mean (B)	3.632	4.360	4.597	4.330	4.313	4.240	
	2011 - 2012 season						
Nov.	3.051	3.638	4.149	3.774	3.783	3.774	3.695
Dec.	2.944	3.897	4.162	3.840	3.805	3.890	3.756
Jan.	3.034	4.011	4.225	4.072	3.912	3.900	3.859
Mean (B)	3.010	3.849	4.179	3.896	3.833	3.855	

LSD 0.05 2010 – 2011 season: A. 0.068 B. 0.096 A×B. 0.166

LSD 0.05 2011 – 2012 season: A. 0.088 B. 0.125 A×B. 0.216

Table 8: Effect of boron spray on stone weight (gm) in 2010/2011 and 2011/2012 seasons

	Stone weight (gm)						
	Boron Conc. (mg.L^{-1})						
Time	0.00	100	200	300	400	500	Mean (A)
	2010 - 2011 season						
Nov.	0.775	0.702	0.697	0.704	0.780	0.858	0.753
Dec.	0.788	0.814	0.691	0.781	0.851	0.853	0.796
Jan.	0.781	0.619	0.716	0.755	0.901	0.876	0.775
Mean (B)	0.781	0.712	0.701	0.747	0.844	0.862	
	2011 - 2012 season						
Nov.	0.744	0.546	0.572	0.655	0.740	0.694	0.659
Dec.	0.642	0.609	0.581	0.640	0.732	0.733	0.656
Jan.	0.625	0.436	0.554	0.625	0.770	0.695	0.617
Mean (B)	0.670	0.530	0.569	0.640	0.748	0.707	

LSD 0.05 2010 – 2011 season: A. N.S B. 0.074 A×B. 0.129

LSD 0.05 2011 – 2012 season: A. N.S B. 0.061 A×B. 0.105

Table 9: Effect of boron spray on oil percentage in 2010/2011 and 2011/2012 seasons

Olive oil %							
	Boron Conc. (mg.L^{-1})						
Time	0.00	100	200	300	400	500	Mean (A)
			2010 - 2011 season				
Nov.	22.13	24.28	24.42	24.12	23.96	23.98	23.81
Dec.	22.17	24.29	24.27	24.17	23.92	23.89	23.78
Jan.	22.35	24.49	24.38	24.37	24.08	24.03	23.95
Mean (B)	22.22	24.35	24.36	24.22	23.99	23.97	
			2011 - 2012 season				
Nov.	22.47	24.89	25.45	25.51	25.42	25.20	24.82
Dec.	22.97	25.02	25.40	25.47	25.44	25.31	24.93
Jan.	22.74	25.19	25.58	25.49	25.47	25.43	24.98
Mean (B)	22.72	25.03	25.48	25.49	25.44	25.31	

LSD 0.05 2010 – 2011 season: A. N.S B. 0.406 A×B. 0.704

LSD 0.05 2011 – 2012 season: A. N.S B. 0.319 A×B. 0.553

The maximum increase was recorded with 200 mg.L^{-1} boron rate. Boron applied in January was more effective in increasing fruit flesh weight than when applied in November or December.

Results in Table (6) show that percentage of fruit flesh weight has the same trend as the fruit flesh weight. Percentage of fruit flesh weight was increased in response to boron foliar application comparing with the control. However, there were no significant differences between the times of boron application on the percentage of fruit flesh weight.

Fruit Size: Results in Table (7) show a significant increase in fruit size in response to boron foliar application comparing with the control. The maximum increase in fruit size was achieved with 200 mg.L^{-1} boron rate. There were no significant differences between fruit size with the high boron rates (300, 400 and 500 mg.L^{-1}). The high rates were less effective in increasing fruit size than the low rates (100, 200 mg.L^{-1}). Boron applied in January resulted in higher fruit size than boron applied in November or December.

Although boron application resulted in an increase in fruit set and yield it did not reduce fruit size. This finding agree with Perica *et al*. [10] who related the increase in yield and fruit size to the increase in photosynthetic capacity and/or to an improvement in sink strength of the fruit.

Stone Weight: Results in Table (8) show that stone weight was decreased at low boron rates (100, 200, 300 mg.L^{-1}), however, it was increased at higher boron rates (400, 500 mg.L^{-1}) relative to the control. The maximum reduction was observed at 200 mgL^{-1} boron rate.

There were no significant differences in stone weight among the three times of boron application (November, December, January).

Oil Percentage: Results in Table (9) show a slight increase in olive oil percentage in response to boron foliar application comparing with the control. The increment was higher at the second season than the first season. However, there were no significant differences in oil percent among the different boron application rates and the three times of boron application. Olive trees sprayed with 200 mg.L^{-1} boron rate gave the highest fruit oil percentage.

The total oil content (oil yield) was significantly increased in response to boron foliar application. The results agreed with those of Wiesman *et al*. [24] who found a great increase in olive oil content due to boron treatments.

REFERENCES

1. M.A.L.R., 2013. Ministry of Agriculture and Land Reclamation, Bulletin of the Agriculture Statistics Part 2.
2. Christensen, L.P., R.H. Beede and W.L. Peacock, 2006. Fall foliar sprays prevent boron-deficiency symptoms in grapes. California, Vol. 60 No. 2, UC Cooperative Extension.
3. Liakopoulos, G. and G. Karabourniotis, 2005. Boron deficiency and concentration and composition of phenolic compounds in *Olea europaea* leaves: a combined growth chamber and field study. Tree Physiology, 25(3): 307-315.

4. Stellacci, A.M., A. Caliandro, M.A. Mastro and D. Guarini, 2010. Effect of foliar boron application on olive *Olea europaea* L. fruit set and yield. Acta Hort., 868: 267-272.
5. Gupta, U.C., 1979. Boron nutrition of crops. Adv. Agron., 31: 273-307.
6. Nyomora, A.M.S., 1995. The effect of boron deficiency on the reproductive processes of almond (*Prunus dulcis [Mill] D.A. Webb*) Ph.D. dissertation, Univ.California, USA.
7. Tsadilas, C.D. and K.S. Chartzoulakis, 1999. Boron deficiency in olive trees in Greece in relation to soil boron concentration. Acta Hort., 474: 341-344.
8. Jones, J.B., B. Wolf and H.A. Mills, 1991. Plant analysis Handbook., Micro-Macro Publishing, Inc.
9. Amin, P.S. and A.R. Shahsavar, 2012. The influence of urea, boric acid and zinc sulphate on vegetative traits of olive. J. Biol. Environ. Sci., 6(16): 109-113.
10. Perica, S. P.H. Brown, J.H. Connell, A.M.S. Nyomora, C. Dordas and H. Hu, 2001. Foliar boron application improves flower fertility and fruit set of olive. HortScience., 36(4): 714-716.
11. Spinardi, A. and D. Bassi, 2012. Olive fertility as affected by cross-pollination and boron. The Scientific World Journal, Vol. 2012, article ID 375631.
12. Ahmed, F.F. and M.H. Morsy, 1999. A new method for measuring leaf area in different fruit species. Minia J. of Agric. Res & Develop., 19: 97-105.
13. Hegazi, E.S. and G.R. Stino, 1982. Dormancy, Flowering and sex expression in 20 olive cultivars Acta. Agrobot., 35: 1-53.
14. Hegazi, E.S. and A.A. Hegazi, 2005. Evaluation of 12 olive cultivars introduced to Egypt under Giza conditions I. floral biology and fruiting. Proceeding of the six Arabian conference for horticulture, March 20-22, Fac. Agric. Ismaelia.
15. Hegazi, E.S., 1970. Studies on growth, flowering and fruiting of some olive seedling strains under Giza condition M.Sc. Thesis. Fac. Agric.Cairo Univ. Egypt.
16. Mstat, 1989. A microcomputer program for the design management and analysis of agronomic research experiments. Michigan state university.
17. Snedecor, G.W. and W.D. Cochran, 1980. Statistical methods. 7th edition Iowa State University Press, Ames, Iowa., U.S.A.
18. Nyomora, A.M.S., P.H. Brown and M. Freeman, 1997. Fall foliar-applied boron increases tissue boron concentration and nut set of almond. J. Amer. Soc. Hort. Sci., 122: 405-410.
19. Talaie, A. and M. Taheri, 2001. The effect of foliar spray with N, Zn and B on the fruit set and cropping of Iranian local olive trees. Acta Hort., (ISHS), 564: 337-341.
20. Kilby, M.W., R. Neja and R. Call, 1998. Foliar applications of boron to pecan trees does not affect fruit set. Citrus and deciduous fruit and nut Res. Report. Univ., Arizona publication.AZ1051.
21. Pedo, S.O. Failla, D. Bassi and C. Gigliotti, 2005. Critical boron levels in the leaves of an olive grove in north Italy. Informatore-Agrario, 61(22): 40-42.
22. Dickinson, D.B., 1978. Influence of borate and pentaerythritol concentration on germination and tube growth of lilium longif. J. Amer. Soc. Hort. Sci., 103: 413-416
23. Marschner, H., 1995. Mineral nutrition of higher plants. 2nd edition. Academic Press, London, UK.
24. Weisman, Z., A. Ronen, Y. Ankarion, S. Maranz, B. Chpagain and Z. Abramovich, 2002. Effect of olive-Nutri-vanton yield and quality of olive and oil. Acta Horticulture, 594: 557-562.