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Effect of Foliar Application of Boron and Zinc on Fruit Set, Yield and Some Fruit Characteristics of Fuerte Avocado.

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ABSTRACT

This study was carried out on Fuerte avocado trees (18 years old) grown at Horticulture Research station, Seds, Beba, Bani-Sueif Governorate during the successive season 2013 and 2014 for improving tree productivity, yield and some fruit characteristics. In this concern, trees were spray with Boron as Borax (17.5% B) in concentrations of 0.0 , 1 g/L and 2 g/L and Zn as Zinc sulphate monohydrate (35% Zn) in concentrations of 0.0, 1g/L and 2g/L. each element was sprayed independently or in combination three times. The first spray was performed at the beginning of flower bud induction in October, the second spray was at bud Burst during last week of January and the third one was at anthesis in the first week of April. Pollen germination, fruit set percentages, number of fruit per tree as well as yield per tree, fruit weight, length and the greatest breadth of fruit, fat percentage, flower and leaf contents of B and Zn and leaf content of chlorophyll were determined to assess the effect of the treatments.The obtained results showed that, B and Zn were significantly affected on improving pollen germination; fruit set number as well as yieldper tree. Furthermore, B and Zn treatments increased fruit weight, length and the greatest breadth of fruit;however, there were no significant differences between the tested treatments on fat percentage. Foliar application of B and Zn increased flower content of B and Zn as compared with leaf content and the high concentrations of Band Zn gave the highest values in this concern.Moreover, chlorophyll index increased in leaf of treated trees as compared with control ones. The study also showed that, B was more effective than Zn in most treatments and the combinations of B + Zn were having positive synergistic effect which the treatment of commination 1g/L of B+ 1g/L of Zn gave the highest values in comparison of other testes treatments and control .

Keywords: Avocado- Boron-Zinc- pollen germination – fruit set – quality – vegetative growth- leaf analysis-chlorophyll-combination.

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INTRODUCTION

Boron is a nutrient has influences the effective of pollination period in avocado. It is well documented that boron is essential for pollen germination, for successful growth of the pollen tube through the stigma, style and ovary to the ovule, and for the miotic divisions necessary to produce the sperm and egg [1]. Benefits from boron sprays are less likely when conditions are optimal for fruit set. Thus, there has been considerable interest in the use of boron fertilization to increase fruit set in the avocado [2-5]. Hass avocado fruit set and yield increased as response to the boron spray, if the concentration in the leaves close to the shoot tip was sufficiently high well in advance of flowering [3,6,7]. Boron spray applied either during fall or spring to deciduous fruit tree species not deficient in boron based on leaf analysis have proven effective in increasing fruit set and yield [8].Especially when cool temperature and overcast or wet weather prevail during bloom [9,10].There was always an increase in yield in response to B, but some experiments or in some years, only marginal improvement over the control trees was obtained [11]. Boron and Zinc deficiencies are more probable early in the season because the translocation of elements from the root to the above ground portion may not be adequate before leaf expansion [12]. Zinc and Boron have critical effect on flowering and fruit set for this reason, spring foliar applications of these elements are frequently recommended in fruit orchards. In soil with a strong Zn fixation capacity, spraying foliar fertilization has several advantages including low application rate, uniform distribution of fertilizer materials, efficacy before leaf development and quick response [13]. Boron plays an important role in pollen germination and pollen tube growth [14] and foliar sprays of B increase pollen germination in number of tree species including almond [15]; Pear[16] and meyerspruce [17] and increase fruit set in almond [18-20], Sweet cherry [21], hazelnut [22]. Foliar applications of zinc have been successfully used to promote tree vigor, fruit set and yield [23]. The possible synergestic effect of combined B and Zn application has been examined in several species. Foliar application of B and Zn simultrancoushy in almond trees, increased fruit set, by 38%, whereas when B and Zn was applied alone fruit set was 27.7% and 22.2% respectively [24,25] on walnut. Combined foliar application of B and Zn on sweet cherry increased fruit set and yield to great extent than application of element alone [21]. Both Zn and B application have a positive effect on leaf chlorophyll content in B and Zn deficient plants [26,25]. The foliar application macro and micro-nutrients have very important role to improve fruit set, productivity and quality of fruit. It has also beneficial role in recovery of nutritional and physiologicaldisorders in fruit trees. Various experiments have been conducted ear layer on foliar spray of micro-nutrients in different fruit crops and shown significant response to improve yield and quality of fruits [27,28].

The purpose of this investigation was to overcome the Dichogamy phenomenon of avocado flower by determine the most effective concentration and combination of B and Zn to increase pollen fertility, fruit set and yield and improving some fruit characteristics.

MATERIALS AND METHODS

This experiment was conducted on Fuerte avocado trees aged of 18 years old during the two successive seasons 2013 and 2014. Avocado trees were growing loamy soil at the Horticulture Research Station - Seds, Beba, Bani-Sueif Governorate. The chosen trees were grafted on avocado seedling rootstocks, planted at 5m X5m spaces, irrigated with flood irrigation system and subjected to the normal annual agricultural practices. Twenty seven trees visually similar in morphological features such as canopy, volume and trunk diameter were chosen and labeled.

Nine treatments were prepared as following:

1. Trees were sprayed with tap water (untreated) as control.
2. Trees were sprayed with Boron at 1g/L.
3. Trees were sprayed with Boron at 2g/L.
4. Trees were sprayed with Zinc at 1g/L.
5. Trees were sprayed with Zinc at 2g/L.
6. Trees were sprayed with B 1g/L + Zn 1g/L.
7. Trees were sprayed with B 1g/L + Zn 2g/L.
8. Trees were sprayed with B 2g/L + Zn 1g/L.
9. Trees were sprayed with B 2g/L + Zn 2g/L.

Boron was used as Borax (17.5% B) and Zn was used as sulphate monohydrate (35%Zn). Each treatment was consists of 3 replicates (3 trees) with two factors B and Zn and combination (B + Zn). All chosen trees were sprayed three times in each season. The first spray was performed at the beginning of flower bud induction in October, the second spray was carried at bud burst during last week of January and the third spray was done at anthesis in the first week of April.

Pollen germination percentage:

Pollen grains were collected during anthesis stage. Flowers in the male stage of the reproductive cycle were collected in paper bags then brought into the laboratory. After anther dehiscence when pollen shed over they collected and incubated in petri dishes on a medium containing 15% sucrose and 0.8% agar according to [29]. Pollen germination was recorded after 6 h. as the percentage of germinated pollen in a total of 500 grains from different areas of plate. Each pollen sample was replicate three times. Pollen was considered to have germinated if pollen tube length was at least twice as long as the diameters of grain [29] samples were observed by Optical microscope.

Fruit set %, number of fruit and yield per tree (kg):

Tree representative branches were selected from each treated tree to monitor the total numbers of fruits. On the last week of August just at harvest time the number of fruit per branch was counted to estimate the final fruit set (Number of fruit per branch / number of initial flower X 100). At harvest date, total of fruit number per tree was collected and yield was determined as Kg/tree (Total number of fruit/tree X Average fruit weight (gm)/ 1000).

Fruit characteristics:

Samples of five fruits from each treated tree and untreated (control) trees were collected at maturity stage to estimate some properties i.e. fruit weight (gm), fruit length (cm) and the greatest breadth (cm). When fruit were reached ripe stage, samples of 5 fruits were cut into quarters and peeled, the seed coat removed and the flesh pooled and homogenized by a pestle. The fatty acid methyl esters were prepared using solution of methylalcohol, benzene, 2,2-dimethoxy propane, sulphuric acid (37:20:5:2 v/v/v/v) and n.heptane was used for separation of methyl esters as described previously [30]. Free fatty acids were identified by comparison of retention time of the gas chromatographic peaks with these of commercial free fatty acid methyl ester standards. They were automatically computed as a percentage by the data processor (Chrom-card) from the ratio of individual peak area to the total peaks area of fatty acids.

Flower part and leaf analysis:

At anthesis stage, samples of 50 flowers from each tree were collected in paper bags then taken to the laboratory and were shed by tap and distilled water then lefted to shade dried. Afterthat, flower parts were dried in hot air oven at 70°C for 48 h. then grounded into fine powder by using mixture and stored in paper bags for analysis.

Samples of 30 leaves from each treated tree were collected from the basal 10th leaf of the shoot all around the tree canopy at harvest date. Leaf samples were washed by tap and distilled water then shade dried in hot air oven at 70°C for 48 h. and grounded by using mixture.

Boron was measured with the curcumin spectrophotometric method according to [31]. Zn concentration was determined by atomic absorption spectrometer.

Chlorophyll measurements were collected with at hand –held dual wave length chlorophyll meter. On each tree four leaves were sampled from four shoots located at midhight of the canopy in the four cardinal directions (16 values per tree). The mean of these 16 readings was used for all treatment comparisons.

The aim of this study was to overcome the Dichogamy phenomenon of avocado flower and assess the beneficial concentration of B and Zn and the most effective combination for improving yield and some fruit quality.

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Statistical analysis:

Statistical analysis of the data was thoroughly out and the individual comparisons were compared by using the New least significant Differences (New L.S.D) according to [32]. Interaction studies were carried out and calculated as refered by [33].

RESULTS AND DISCUSSION

Effect of foliar B and Zn applications on pollen germination percentage fruit set, number of fruit per tree and yield:

As shown in Table (1) B at 1g/L concentration was more effective than B at 2g/L in relation at pollen germination percentage, fruit set, number of fruit per tree and yield. Furthermore, Zn at 1g/L and 2g/L concentrations were significant when sprayed each alone resulted in an increase in germination percentage of pollen grains, fruit set, number of fruit per tree and yield as compared with untreated (control). Boron treatments were more effective as compared with Zn in this concern. However, the possible synergestic effect of combined B and Zn has been observed also in Table (1) which the highest values of pollen germination percentages (84.50 and 87.00 %), fruit set (27.40 and 27.60 %), number of fruits per tree (153 and 162 fruits) and yield (28.50 and 31.30 kg) were obtained from foliar application mixture of B at 1g/L +Zn at 1g/L in both examined seasons, respectively. The effect of foliar B and Zn on pollen germination, fruit set and yield has been demonstrated in many fruit trees [12]. A clear effect of combination of these elements was positively on pollen germination, fruit set and yield [25]. Boron plays an important role in pollen germination and pollen tube growth [14]. Foliar spray of B had a markedly increase of pollen germination in number of fruit tree species namely almond [18], meyer spruce [17] and pear [16] and also increased fruit set in almond, sweet cherry , hazel nut and apple [21-22]. Foliar applications of Zn have been success fully used to promote tree vigor, fruit set and yield [23]. The foliar application of macro and micro nutrients have very important role in improving fruit set, productivity and quality of fruits. It has also beneficial role in recovery of nutritional and physiological disorder on foliar spray of micro-nutrients in different fruit crops and shown significant response to improve yield and quality of fruits [27,28].

Table 1: Effect of foliar Boron and Zinc applications on pollen germination, fruit set, number of fruit and yieldper tree of Fuerte avocado trees during 2013 and 2014, seasons.

Treatments		Pollen germination%		Fruit set % Per tree		No. of fruit/tree		Yield (kg) Per tree	
		2013	2014	2013	2014	2013	2014	2013	2014
Untreated (control)		52.30	54.10	14.80	13.10	94	97	13.30	13.70
Br at 1 g/L		78.50	80.30	21.50	21.70	138	142	22.60	23.20
Br at 2 g/L		69.40	70.60	20.00	19.40	129	131	20.20	20.70
Zn at 1g/L		66.00	65.90	16.30	17.20	106	109	16.10	16.40
Zn at 2g/L		67.00	66.20	15.60	17.40	112	118	16.90	18.10
Br +Zn (1g+1g/L)		84.50	87.00	27.40	27.60	153	162	28.50	31.30
Br +Zn (1g+2g/L)		79.40	79.70	23.20	24.80	138	144	23.60	24.40
Br +Zn (2g+1g/L)		73.20	70.80	20.50	21.20	134	137	22.40	22.60
Br +Zn (2g+2g/L)		74.10	76.00	22.10	22.70	136	140	23.00	23.60
New L.S.D at 0.05	Br	4.80	4.40	1.70	2.10	5.70	5.90	3.60	4.10
	Zn	3.70	3.60	1.30	1.10	4.60	4.80	2.70	2.40
	Br *Zn	4.70	4.20	1.50	1.40	6.10	6.30	3.50	3.80

Effect of foliar B and Zn applications on some fruit characteristics:

Table (1) indicated that sprayed combination of B and Zn resulted in more response than sprayed either element supplied individually and was significant. Fruit weight increased by both B and Zn treatments at different concentrations used as compared with untreated (control). Fruit length and the greatest breadth also significantly increased by B and Zn treatments while percentage of fat in avocado fruit gave insignificant differences between different treatments and untreated (control). Furthermore, the all combination treatments of B and Zn have asynergistic effect on fruit weight as compared with B or Zn sprayed individually at different concentrations. The highest values of fruit weight (186.10 and 193.20 gm) were obtained from

foliar application of B at 1g/L + Zn at 1 g/L in both studied seasons, respectively. Moreover, fruit length and the greatest breadth of fruit were significantly increased by combination of B and Zn treatments, while no significant differences were noticed in fat percentage, this is clear in both tested seasons and Table (2).

These results are in general concurrence with [27,25,28] who demonstrated that, foliar spray of micro nutrients shown significant response to improve yield and quality of fruit. However, [2,3] found that, there was always an improve in fruit quality and yield in response to Boron, but in some experiments or in some years, only marginal improvement over the control trees was obtained.

Table 2: Effect of foliar Boron and Zinc applications on fruit weight, fruit length, greatest breadth and percentage of fat in Fuerte avocado trees during 2013 and 2014, seasons.

Treatments		Fruit weight (gm)		fruit length (cm)		greatest breadth (cm)		Fat %	
		2013	2014	2013	2014	2013	2014	2013	2014
Untreated (control)		141.60	138.10	9.30	8.70	6.10	6.20	26.30	26.40
Br at 1 g/L		164.00	163.70	10.00	9.90	7.30	7.30	26.80	26.70
Br at 2 g/L		156.40	157.00	9.80	9.60	6.70	6.40	26.50	26.50
Zn at 1g/L		150.70	153.20	9.50	9.40	6.30	6.20	26.30	26.50
Zn at 2g/L		151.40	150.60	9.40	9.40	6.20	6.20	26.60	26.50
Br +Zn (1g+1g/L)		186.10	193.20	11.10	11.30	8.10	7.90	26.90	26.90
Br +Zn (1g+2g/L)		170.80	170.10	10.20	10.00	7.40	7.50	26.80	26.80
Br +Zn (2g+1g/L)		167.30	164.30	10.00	9.60	7.30	7.50	26.70	26.80
Br +Zn (2g+2g/L)		169.00	168.40	10.00	10.00	7.60	7.60	26.70	26.80
New L.S.D at 0.05	Br	4.30	5.10	0.30	0.40	1.10	1.00	N.S	N.S
	Zn	3.20	3.70	0.10	0.10	0.70	0.60	N.S	N.S
	Br *Zn	5.10	4.80	0.40	0.30	1.20	1.10	N.S	N.S

Effect of foliar B and Zn applications on flower parts and leaf content of B and Zn and chlorophyll index:

Flower parts and leaf analysis in Table (3) showed that, B content in flower parts was found highest due to foliar spray of Boron individually or in combination with Zn as compared with untreated trees. Meanwhile, Zn content also was found maximum in flower parts when Zn sprayed alone or in combination with B. However, B and Zn content in leaf increased with increasing B and Zn concentration not only each alone but also in combinations. The obtained results cleared that, treatment of 2g/L B + 2g/L gave the highest flower and leaf contents of B and Zn. However, accumulation of B and Zn in flower parts were higher (30.00 and 30.18) of B ; (29.13 and 29.76)of Zn than (27.76 and 27.87)of B; (25.47 and 25.94) of Zn in leaf of treated tree in both studies seasons, respectively. A positive synergestic effect was found where all combination treatments were superior in this concern than individually B or Zn treatments.

Chlorophyll content in leaf of treated trees increased by foliar B and Zn applications as compared with untreated (control) trees. The combination of B and Zn has a positive synerestic effect especially whensprayed B at 1 g/L + Zn at 1g/L treatment were conducted. which gave the highest chlorophyll index (47 and 46) as compared with (30 and 31) for untreated trees in both examined seasons, respectively. Generally, all B or Zn treatments as foliar applications increased leaf chlorophyll index when sprayed individually or in combinations in conparation with untreated trees, this is clear in both seasons Table (3). These results are confirmed the finding of [10] who found that, B accumulations in flower buds and flower parts, B levels are higher in floral than in vegetative tissues sygesting a specific in evolvement of B in the reproductive process. Moreover, the Zinc content was found maximum in the leaf due to foliar spray of micronutrients [28]. Both Zn and B applications has a positive effect on chlorophyll contents in B and Zn deficient plants [26,12,23,25].

In conclusion the obtained results of this investigation highlights the role of Boron and Zinc in improving pollen germination, fruit set percentage, number of fruit per tree and subsequently yield per tree. Meanwhile, foliar B and Zn applications improved also some fruit characteristics while. No significant different were observed in fat percentage. Accumulation of B and Zn were higher in flower parts than leaf and all foliar B and Zn sprays were significantly affected in increasing B and Zn contents in flower and leaf tissues. Chlorophyll index was higher in leaf of tree sprayed with B and Zn. A synergestic possible effect was found in combination of B and Zn which the most effective treatment was (B at 1g/L + Zn at 1g/L).

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Table 3: Effect of foliar Boron and Zinc applications on flower parts, leaf content of Br & Zn and leaf content of chlorophyll in of Fuerte avocado trees during 2013 and 2014, seasons.

Treatments		Flower parts				Leaf					
		Br (ppm)		Zn (ppm)		Br (ppm)		Zn (ppm)		Chlorophyll	
		2013	2014	2013	2014	2013	2014	2013	2014	2013	2014
Untreated (control)		16.01	16.43	18.81	18.66	15.11	15.20	16.40	16.76	30	31
Br at 1 g/L		27.16	28.80	19.10	19.17	20.27	20.61	16.46	16.73	43	43
Br at 2 g/L		29.14	29.27	19.16	19.34	23.15	23.38	16.63	17.01	40	39
Zn at 1g/L		18.32	18.50	23.79	24.08	17.44	16.96	22.87	22.66	43	44
Zn at 2g/L		18.71	18.86	25.04	26.13	17.04	17.23	23.04	23.80	41	42
Br +Zn (1g+1g/L)		28.69	29.71	26.96	28.61	25.61	25.45	24.18	24.73	47	46
Br +Zn (1g+2g/L)		28.81	28.96	28.81	28.42	26.43	26.68	26.31	26.65	43	45
Br +Zn (2g+1g/L)		29.01	29.17	28.24	28.12	26.72	26.63	25.44	25.16	44	44
Br +Zn (2g+2g/L)		30.06	30.18	29.13	29.76	27.76	27.87	25.47	25.94	45	45
New L.S.D at 0.05	Br	3.90	4.10	2.60	2.80	2.90	3.10	2.10	1.90	1.60	1.40
	Zn	2.70	3.10	3.40	3.70	1.60	1.40	2.40	2.60	2.10	2.30
	Br *Zn	4.60	4.70	3.80	4.10	3.10	2.80	2.80	3.10	2.40	2.60

CONCLUSION

The obtained results of this investigation highlights the role of Boron and Zinc in improving pollen ermination, fruit set percentage, number of fruit per tree and subsequently yield per tree. Meanwhile, foliar B and Zn applications improved also some fruit characteristics while. No significant different were observed in fat percentage. Accumulation of B and Zn were higher in flower parts than leaf and all foliar B and Zn sprays were significantly affected in increasing B and Zn contents in flower and leaf tissues. Chlorophyll index was higher in leaf of tree sprayed with B and Zn. A synergestic possible effect was found in combination of B and Zn which the most effective treatment was (B at 1g/L + Zn at 1g/L).

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