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Influence of Foliar Spraying with Boron and Calcium on Productivity, Fruit Quality, Nutritional Status and Controlling of Blossom End Rot Disease of Anna Apple Trees

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Abstract: The present work was carried out during two successive seasons 2007 and 2008 on four year's old Anna apple trees budded on Balady apple rootstock, grown on sandy soil at (4 X 4 m) apart under drip irrigation system, in a private farm at El-Khatatba region, Minufiya governorate, Egypt. This work amid to study influence of foliar spraying with boron (as boric acid) and calcium (as calcium chloride) on productivity, fruit quality, nutritional status and controlling of blossom end rot disease of Anna apple trees. Boric acid at concentrations of 0.0 % (B_0), 0.025 % (B_1), 0.05 % (B_2) & 0.1 % (B_3) and calcium chloride at concentrations of 0.0 % (Ca_0), 0.1 % (Ca_1), 0.2% (Ca_2) & 0.4 % (Ca_3) were sprayed twice, where the first was after petal fall and the second after fruit set. Results showed that foliar spraying of boric acid and calcium chloride alone or as combinations significantly increased fruit yield, yield attributes and improved fruit physical and chemical properties as well as enhanced the nutritional status of apple trees. The treatments clearly decreased the percentage of incidence and severity of blossom end rot disease compared with the unsprayed treatment in two seasons. Disease incidence was from 4.7 to 11.1 % with boric acid, from 3.6 to 6.6 % with calcium chloride and from 0.5 to 2.9 % with their combinations, comparing with 18.9 and 17.7 % in the control in the two seasons. The disease severity was from 10.0 to 16.0 % with boric acid, 7.3 to 14.7 % with calcium chloride and 2.7 to 13.3 % with their combinations, comparing with 36.0 and 32.7 % in the control plants in both seasons. The higher level of both boric acid and calcium chloride showed a remarkable improvement in most studied characteristics. The best results were obtained from the combination treatment of 0.1% boric acid plus 0.4% calcium chloride and it is recommended for high productivity and fruit quality of Anna apple trees.

Key words: Apple · Boron · *Malus domestica* · *Botrytis cinerea* · Calcium · Blossom end rot · Nutritional status · Fruit quality

INTRODCTION

Anna apple cultivar (*Malus domestica*, Borkh) is considered one of the most important fruit crops, which cultivated in the newly reclaimed sandy soil in Egypt. Deficiency of micronutrients in such areas of soils have been shown as yield- limiting factor [1,2]. Foliar application of micronutrients was successfully used for correcting their deficits in crops [3]. Boron is an essential micronutrient required for optimal yield and quality of apple fruit [4-6]. Boron availability to plants decreases with increasing soil pH and / or under drought conditions [7].

Apple trees have high boron requirements and it is important in pollen germination, pollen tube growth, successful fruit set and formation of feeder roots.Symptoms of boron deficiency in apples include internal and external core formation in the fruit and the development of small-deformed fruits [8, 9].

Apple leaves analysis frequently shows a need for higher calcium levels [2, 10].Low calcium level in fruit causes several disorders, the major ones being bitter pit, cork spot and senescent breakdown during storage. Apples are not efficient in obtaining calcium from soil and also are not efficient in translocation calcium from the roots to the leaves and fruit. Therefore, the foliar spraying

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of calcium on apple trees is commonly used to increase calcium content of fruits and leaves. Huguet [11], Stahly [12] and Saure [13] emphasized the important role of calcium in prolonging shelf-life of fruits and improving growth, nutritional status, productivity, resistance to pathological disorders and quality of the fruits.

Botrytis cinerea is a common fungus that can cause fruit rot problems in the field and post-harvest in pome fruits. It is considered a minor problem in the field, but can contribute to post-harvest losses in packinghouse. The disease attacks the blossom end of apple fruit. Brown rotted patches develop at the blossom (the end opposite to stem attachment) of the fruit.The infection is likely to occur during blooming, although it is not visible until several weeks. Chemical control of diseases caused by fungal pathogen largely depend upon the benzimidazole and dicarboximide fungicides [14].Various integrated pest management (IPM) approaches have been investigated or proposed to reduce the fungicide application [15]. The new control strategy such as appropriate fertilization is fundamental to adequate disease control [16]. The pre-harvest sprays of calcium ion has bean promising to control the fungal pathogen when used in various forms such as sulfate ($CaSO_4$), chloride ($CaCL_2$) and / or nitrate ($Ca(NO_3)_2$) [17]. Spraying roses with calcium sulfate at 10mM or 20 mM one day before harvest is recommended to control *B. cinerea* after harvest [18].

This study aimed to examine the probably effect of boron (as boric acid) and calcium (as calcium chloride) foliar application on fruit yield, fruit quality, controlling the blossom end rot disease, nutritional status of apple trees as well as the relationship between the leaf nutrients content of apple trees and the percentage of incidence and severity of blossom end rot disease.

MATERIALS AND METHODS

The present study was performed during two successive seasons (2007and 2008 seasons) on four years old Anna apple trees (*Malus domestica*, Borkh), budded on Baladi apple (Indian crab) rootstock. Trees were spaced 4 x 4 m apart grown in a private farm at El-khatatba district, Minufiya governorate. All trees were almost uniform in vigor, grown in a sandy soil under conventionally accepted practices, using drip irrigation system and macro and micronutrients were added as recommended of ARC [19].

Table 1: Some physico-chemical properties of soil sample from the experimental site

Properties	Items
Sand %	88.8
Silt %	7.2
Clay %	4.0
Texture	Sandy
pH (1:2.5 soil: water)	8.86
E.C.(1:2.5 soil: water) dS/m	0.16
$CaCO_3$ %	2.8
Organic matter %	0.51
Available Macronutrients (mg/100g soil)	
P	1.8
K	10.45
Mg	12.6
Ca	190
Na	20.24
Available Micronutrients (mg/ Kg soil)	
Fe	2.0
Mn	3.1
Zn	0.2
Cu	0.3
B	0.27

Table 2: The experimental treatments

	Calcium chloride %			
Boric acid %	0.0	0.1	0.2	0.4
0.0	B_0- Ca_0	B_0- Ca_1	B_0- Ca_2	B_0- Ca_3
0.025	B_1- Ca_0	B_1- Ca_1	B_1- Ca_2	B_1- Ca_3
0.05	B_2- Ca_0	B_2- Ca_1	B_2- Ca_2	B_2- Ca_3
0.1	B_3- Ca_0	B_3- Ca_1	B_3- Ca_2	B_3- Ca_3

Soil Analysis: Soil sample from the experimental site (0-50 cm, deep) was taken to determine some physico-chemical characteristics (Table, 1). The following analyses; texture; pH & E.C. ; organic matter ; calcium carbonate [Ca CO_3] ; available potassium (K),sodium (Na),calcium (Ca) & magnesium (Mg) ; phosphorus (P) ; Available micronutrients, iron (Fe), manganese (Mn), zinc (Zn) and copper (Cu) and boron (B) were determined according to standard procedures [20-22].

Boron and Calcium Treatments and Application: Boron as boric acid at concentrations of 0.0 % (B_0), 0.025 % (B_1), 0.05 % (B_2) and 0.1 % (B_3) and calcium as calcium chloride at concentration of 0.0% (Ca_0), 0.1% (Ca_1), 0.2% (Ca_2) and 0.4 % (Ca_3). Forty-eight uniform trees were chosen randomly in a randomized block design with three trees as replicates for each treatment. Anna apple trees were sprayed two times in each season. The first spray was after petal fall (3 rd week of March) and the second spray at two weeks after fruit set (3 rd week of April). All spray solutions contained 0.1 % of triton B as a wetting agent. The experimental treatments were as in Table 2.

Macro and Micronutrients Analysis of Apple Leaves: Samples of fully mature leaves were randomly taken from the trees of each replicate after two weeks from the second spray of boric acid and calcium chloride. The dry ashing technique was used to extract macro and micronutrients from dried and ground leaves as described by Chapman & Pratt [22], while boron (B) was determined by Azomethine-H colorimetric method according to Wolf [20]. Total nitrogen (N) in leaves was determined by Buechi-320 apparatus, while potassium (K), calcium (Ca) and sodium (Na) were measured using flame photometer, Genway instrument and phosphorus (P) was measured by using Spectrophotometer, Perkin Elemer instrument. The leaves content of iron (Fe), manganese (Mn), zinc (Zn) and magnesium (Mg) were measured by using Atomic Absorption Spectrophotometer, Perkin, Elemer Model 1100B.

Yield (Kg/tree): At harvest time in each season, the fruit yield was estimated for each treatment, separately, on the basis of average of fruits number and fruits weight per tree.

Fruits Characters: Fifteen fruits (as samples) from each replicate were randomly taken for determining the physical and chemical characteristics:

Physical Characters: Fruit weight (g), fruit diameter (cm), fruit length (cm) and fruit length /fruit diameter ratio (L/D ratio) were measured. Fruit firmness was determined as Lb/inch^2 by using fruit pressure tester Mod. FT 327 (3-27 Lbs).

Chemical Characters: The percentage of total soluble solids (TSS %) was determined in fresh fruit juice using a hand refractometer. Total acidity (TA %) was estimated as malic acid according to A.O.A.C [23]. Total sugars content in fruit were determined as g/100 g of fresh fruit weight (Fw) using the phenol sulphoric acid method according to Smith *et al.* [24].

Total anthothianin were determined as mg/100 g of fresh fruit weight (Fw). One gram of fruit skin was ground with mixture of ethanol (95%) and HCL (1%).Then, the mixture filtered through centered glass funnel (G3) and the extract was transferred to 25 ml volumetric flask and completed to volume with the acid alcohol. the increase in optical density at 550 nm represent the concentration of the total anthothianin [25].

Pathological Studies

Isolation of the Causal Pathogen: Random samples of naturally infected Anna apple fruits were obtained from the same private farm in El-Khatatba, Minufiya governorate. The fruits were transferred to laboratory and then stored at cold conditions for isolation. Laboratory isolation from rotted fruits was carried out on Martin's medium [26]. Small pieces (1 cm thick) of rotted fruit were sterilized by dipping into 2% sodium hypochlorite solution for 5 min., then washed several times with sterilized water and finally dried between sterile filter paper [27]. The sterilized pieces placed on surface of medium in sterilized Petri-dishes. Inoculated plates were incubated at 25°C for 5 days. Hyphal tip technique was followed for purification of the isolated fungi.The causal fungus was identified according to their pathogenicity and morphological characters according to Barnett and Hunter [28].

Incidence and Severity of Blossom End Rot Disease: The disease incidence of blossom end rot was calculated as percentage of infected apple fruit in relation to the total number of fruits in each replicate. For calculating the disease severity, rotted apple fruits were classified into six categories (0, 1, 2, 3, 4 and 5) according to decayed area of fruits, i.e. healthy fruit, =10%, 11-20%, 21-50%, 51-70% and 71-100%, respectively [29]. The percentage of disease severity was calculated according to this formula:

$$D.S. = \frac{\sum (nxr_1).....(nxr_5)}{5N} x100$$

Where:
D.S. = Disease severity
n = Number of decayed fruits per category.
$r_1 \ldots r_5$= Category number
N= Total examined fruits.

Statistical Analysis: Data obtained were subjected to Computer Statistical Package (CO-STATE) originated by Anonymous [30].

RESULTS

Effect of Boric Acid and Calcium Chloride Spraying on Yield and Yield Attributes:

Average of Fruit Weight (g): Data in Table 3 showed that the spraying of boric acid or calcium chloride at the tested concentrations significantly gradually increased the average of fruit weight of Anna apple fruits compared

Table 3: Effect of foliar application of boric acid and calcium chloride on the average of fruit weight (g), number of fruit / tree and yield / tree (Kg) of Anna apples in 2007 and 2008 seasons

Treatments	Average fruit weight (g)					Average no. of fruit / tree					Average yield / tree (Kg)				
	Calcium chloride %														
Boric acid %	0.0	0.1	0.2	0.4	Mean	0.0	0.1	0.2	0.4	Mean	0.0	0.1	0.2	0.4	Mean
2007 season															
0.0	99.8	100.2	107.2	117.2	106.1	112.5	142.5	150.5	166.0	142.9	11.3	14.3	16.1	19.5	15.3
0.025	101.2	118.9	124.9	126.0	117.7	121.5	203.5	207.5	209.5	185.5	12.3	24.2	26.0	26.4	22.2
0.05	104.5	126.7	130.9	134.4	124.1	133.5	210.5	212.0	213.0	192.3	14.0	26.7	27.8	28.6	24.3
0.1	109.2	130.1	136.0	143.0	129.6	142.0	215.0	219.0	222.0	199.5	15.5	28.6	29.9	31.8	26.3
Mean	103.7	119.0	124.8	130.2	119.4	127.4	192.9	197.3	202.6	180.1	13.3	23.5	25.0	26.6	22.0
2008 season															
0.0	100.2	107.0	111.9	118.8	109.5	115.0	148.5	151.5	177.5	148.1	11.6	15.9	17.0	20.9	16.4
0.025	102.9	119.9	124.9	129.0	119.2	126.0	208.5	210.5	213.0	189.5	13.0	26.3	26.3	27.4	23.3
0.05	108.7	129.5	134.5	136.6	127.3	138.0	215.0	216.0	216.5	196.4	15.0	27.9	28.5	29.6	25.3
0.1	111.2	131.9	140.5	144.5	131.7	146.0	217.0	219.5	224.0	201.6	16.3	28.9	30.8	31.9	27.0
Mean	105.8	122.1	128.0	132.2	121.9	131.3	197.3	199.4	207.8	183.9	14.0	24.8	25.7	27.5	23.0

LSD 0.05	2007 season			2008 season		
	Ca	B	Ca x B	Ca	B	Ca x B
Av. Fruit weight	2.42	2.48	4.91	2.90	2.90	5.74
Av. Fruit no.	4.26	4.26	8.43	5.25	5.25	10.40
Av. Yield	083	0.83	1.65	2.65	2.65	5.25

with the unsprayed in both seasons. The fruit weight increased with boric acid from 101.2 to 109.2 g and from 102.9 to 111.2 g, with calcium chloride from 100.2 to 117.2 g and from 107.0 to 118.8 g and with their combinations from 118.9 to 143.0 g and from 119.9 to 144.5 g, comparing with 99.8 and 100.2g, in 2007 and 2008 seasons, respectively. The combinations between boric acid and calcium chloride had significant effect on the fruit weight especially at raising both boric acid and calcium chloride concentrations and the highest value of average of fruit weight was attained by the combination of higher concentrations of calcium chloride (0.4%) and boric acid (0.1%) in the two seasons.

Number of Fruits per Tree: As show in Table 3 boric acid and calcium chloride as foliar application significantly increased the average number of fruits per tree, comparing with control treatment. The average fruit number increased with boric acid from 121.5 to 142.0 and from 126.0 to 146.0, with calcium chloride from 142.5 to 166.0 and from 148.5 to 177.5 and with their combinations from 203.5 to 222.0 and from 208.5 to 224.0, comparing with 112.5 and 115.0 in 2007 and 2008 seasons, respectively. Significant differences were obtained between all concentrations of boric acid and calcium chloride in both seasons, except between the lower and the middle concentration of calcium chloride in the second season. Results in Table 3 showed that there was significant effect due to the combination between boric acid and calcium chloride and the highest number of fruit per tree was obtained from the high level of boric acid (0.1%) and calcium chloride (0.4%) in the two seasons.

Yield per Tree (Kg): The fruit yields significantly increased with boric acid from 12.3 to 15.5 kg and from 13.0 to 16.3 kg, with calcium chloride from 14.3 to 19.5 Kg and from 15.9 to 20.9 Kg and with their combinations from 24.2 to 31.8 Kg and from 26.3 to 31.9 kg, comparing with 11.3 and 11.6 Kg in 2007 and 2008 seasons, respectively. The data presented in Table 3 showed that there were significant increments in the yield of Anna apple fruits with increasing boric acid or calcium chloride concentrations comparing with the control in the season of 2007. While, the increments were not reaches to the significant level due to increase the concentration of boric acid (0.025 – 0.050 %) or calcium chloride (0.1- 0.2 %) in the season of 2008. The combination between boric acid and calcium chloride had significant effect on fruit yield (kg / tree) and the highest value was obtained from the highest level of boric acid (0.1%) with the highest level of calcium chloride (0.4%), in the two seasons.

Table 4: Effect of foliar application of boric acid and calcium chloride on some fruit physical characters of Anna apples in 2007 and 2008 seasons

	Fruit Physical characters																			
	Fruit length (Cm) L					Fruit diameter (Cm) D					L / D ratio					Fruit firmness Lb/inch				
Treatments	Calcium chloride %																			
Boric acid %	0.0	0.1	0.2	0.4	Mean	0.0	0.1	0.2	0.4	Mean	0.0	0.1	0.2	0.4	Mean	0.0	0.1	0.2	0.4	Mean
2007 season																				
0.0	6.10	6.30	6.70	6.10	6.30	6.00	6.70	6.60	6.00	6.32	1.02	0.94	1.01	1.02	1.00	11.10	14.30	14.30	15.80	13.88
0.025	5.90	6.80	6.20	6.30	6.30	5.50	6.40	6.10	6.00	6.00	1.09	1.06	1.03	1.06	1.06	11.60	14.40	14.80	15.40	14.05
0.05	6.80	6.40	6.40	6.60	6.60	6.00	6.20	6.10	6.50	6.20	1.15	1.12	1.05	1.05	1.04	11.70	14.60	15.80	16.20	14.58
0.1	6.60	7.10	6.80	6.60	6.80	6.40	6.20	7.10	6.30	6.50	1.05	1.20	0.97	1.07	1.07	11.70	16.30	17.40	18.20	15.90
Mean	6.40	6.70	6.50	6.40	6.50	5.97	6.38	6.48	6.20	6.26	1.08	1.08	1.02	1.05	1.06	11.53	14.90	15.58	16.40	14.60
2008 season																				
0.0	6.40	7.10	6.50	6.50	6.60	5.90	6.80	6.50	6.40	6.40	1.10	1.15	1.01	1.02	1.07	11.40	14.40	12.50	16.50	13.70
0.025	6.50	6.30	6.10	6.50	6.40	5.90	6.50	6.00	5.80	6.05	1.12	1.00	1.05	1.15	1.08	11.60	15.20	15.70	16.30	14.70
0.05	6.60	6.40	6.50	7.00	6.60	6.80	6.40	6.60	6.40	6.55	1.00	1.01	1.01	1.11	1.03	11.60	14.70	15.70	16.50	14.60
0.1	6.40	6.60	6.40	7.10	6.60	6.80	6.30	6.70	6.50	6.58	0.96	1.07	0.96	1.10	1.02	11.70	16.80	17.80	18.90	16.30
Mean	6.50	6.60	6.40	6.80	6.60	6.35	6.50	6.45	6.28	6.40	1.05	1.06	1.01	1.09	1.05	11.50	15.30	15.40	17.10	14.82

		2007 season			2008 season		
LSD 0.05		Ca	B	Ca x B	Ca	B	Ca x B
	Fruit length (L)	0.17	0.17	0.33	0.20	0.20	0.39
	Fruit diameter (D)	0.21	0.21	0.42	0.21	0.21	0.42
	L / D ratio	0.03	0.03	0.06	0.02	0.02	0.04
	Fruit firmness	0.23	0.23	0.45	0.09	0.09	0.19

Table 5: Effect of foliar application of boric acid and calcium chloride on some fruit chemical characters of Anna apples in 2007 and 2008 seasons

	Fruit chemical characters																			
	TSS %					TA %					Total sugars (g/ 100g fw)					Total anthothyianin mg/100g fw)				
Treatments	Calcium chloride %																			
Boric acid %	0.0	0.1	0.2	0.4	Mean	0.0	0.1	0.2	0.4	Mean	0.0	0.1	0.2	0.4	Mean	0.0	0.1	0.2	0.4	Mean
2007 season																				
0.0	11.60	13.20	13.30	12.80	12.70	0.63	0.69	0.69	0.56	0.64	2.55	4.50	5.15	5.30	4.38	0.03	0.04	0.05	0.08	0.05
0.025	11.30	13.40	13.00	12.90	12.70	0.69	0.63	0.56	0.56	0.61	3.75	4.95	5.18	5.35	4.81	0.03	0.05	0.07	0.20	0.09
0.05	12.90	13.30	14.10	14.50	13.70	0.49	0.54	0.49	0.61	0.53	4.35	5.28	5.40	5.13	5.04	0.05	0.44	0.24	0.41	0.29
0.1	13.10	12.30	13.30	12.80	12.90	0.67	056	063	056	0.61	4.23	6.20	6.75	6.80	6.00	0.03	0.31	0.44	0.64	0.36
Mean	12.20	13.10	13.40	13.30	13.00	0.62	0.61	0.59	057	0.60	3.72	5.23	5.62	5.65	5.06	0.04	0.21	0.20	0.33	0.20
2008 season																				
0.0	10.70	12.90	13.60	12.50	12.40	0.61	0.69	0.79	0.52	0.65	2.43	4.93	4.93	4.75	4.26	0.03	0.04	0.04	0.08	0.05
0.025	11.30	12.80	13.50	12.90	12.60	0.55	0.60	0.65	0.65	0.61	3.75	5.38	5.38	5.45	4.99	0.03	0.05	0.07	0.24	0.10
0.05	12.50	12.50	15.20	14.00	13.60	0.56	0.54	0.52	0.63	0.56	4.00	5.45	5.50	5.25	5.05	0.05	0.48	0.31	0.48	0.33
0.1	14.30	12.50	13.30	13.10	13.30	0.71	0.60	0.60	0.54	0.61	4.40	6.50	6.57	6.90	6.09	0.04	0.37	0.44	0.61	0.37
Mean	12.20	12.70	13.90	13.10	12.98	0.61	0.61	0.64	0.59	0.61	3.65	5.57	5.60	5.59	5.10	0.04	0.24	0.22	0.35	0.21

		2007 season			2008 season		
LSD 0.05		Ca	B	Ca x B	Ca	B	Ca x B
	TSS %	0.09	0.09	0.17	0.08	0.08	0.15
	TA %	0.02	0.02	0.03	0.02	0.02	0.03
	Total sugars	0.09	0.09	0.18	0.05	0.05	0.10
	Total anthothyanin	0.01	0.01	0.02	0.01	0.01	0.01

Effect of Boric Acid and Calcium Chloride Spraying on Fruit Physical Characters

Fruit Length (cm) [L]: The fruit length was significantly increased due to foliar spray of boric acid at both middle and higher concentrations in 2007 season and at the middle level only in 2008 season, comparing with the unsprayed control. In addition, the lower and middle concentration of calcium chloride in the first season as well as the lower level only in the second season gave significant increase in fruit length, compared with the control treatment (Table, 4) Results in Table 4 showed that the combination of boric acid and calcium chloride

had significant effects on fruit length in the two seasons. The highest values were obtained from the lower concentration of calcium (0.1%) with the highest concentration of boric acid (0.1%) in the season of 2007 and the combination of the highest concentration of calcium chloride (0.4%) and boric acid (0.1%) in the season of 2008.

Fruit Diameter (cm) [D]: The fruit diameter significantly increased with boric acid from 5.50 to 6.40 cm and from 5.90 to 6.80 cm, with calcium chloride from 6.00 to 6.70 cm and from 6.40 to 6.80 cm and with their combinations from 6.00 to 7.10 cm and from 5.80 to 6.70 cm comparing with 6.00 and 5.90 cm in 2007 and 2008 seasons, respectively (Table 4). The combination of boric acid and calcium chloride had significant effect on fruit diameter of Anna apple in the two seasons. The highest values of fruit diameter were obtained from the highest concentration of boric acid (0.1%) combined with the middle concentration of calcium chloride (0.2%) in both seasons.

L/D Ratio: Data in Table 4 showed that there were significant effects on L / D ratio of Anna apple fruit due to foliar spray of boric acid in the first season and due to only the lower concentrations of boric acid and calcium chloride in the second season. Results also indicated that there was significant effect due to the combination of boric acid and calcium chloride, in both seasons. The highest values of L / D ratio was resulted from the combination of the higher concentration of boric acid (0.1%) with the lower concentration of calcium chloride (0.1%) and the higher concentration of calcium chloride (0.4%) with the lower concentration of boric acid (0.025%) in the 2007 and 2008 seasons, respectively.

Fruit Firmness Lb/inch^2: Results in Table 4 indicated that the fruit firmness of Anna apple was significantly affected by foliar spraying of both boric acid and calcium chloride in the seasons of 2007 and 2008 as compared with control treatment. The fruit firmness increased with boric acid from 11.60 to 11.70 Lb/inch^2 and from 11.60 to 11.70 Lb/inch^2, with calcium chloride from 14.30 to 15.80 Lb/inch^2 and from 12.50 to 16.50 Lb/inch^2 and with their combinations from 14.40 to 18.20 Lb/inch^2 and from 15.20 to 18.90 Lb/inch^2, comparing with 11.10 and 11.40 Lb/inch^2 in 2007 and 2008 seasons, respectively. It is clear that the fruit firmness increased due to increase the concentration of boric acid or calcium chloride in both seasons. Data in Table 4 revealed that there were significant effects due to all possible combinations between boric acid and calcium chloride in both seasons as compared with the control. The highest values were obtained from the combinations of both higher concentrations of boric acid and calcium chloride in both studied seasons.

Effect of Boric Acid and Calcium Chloride Spraying on Fruit Chemical Characters

Total Soluble Solids (TSS %): Data in Table 5 indicate that boric acid and calcium chloride as foliar spray had a positive significant effect on total soluble solids (TSS %) in both seasons as compared with the control treatment. The TSS% increased with boric acid from 11.30 to 13.10 % and from 11.30 to 14.30 %, with calcium chloride from 12.80 to 13.30 % and from 12.50 to 13.60 % and with their combinations from 13.00 to 14.50 % and from 12.50 to 15.20 %, comparing with 11.60 and 10.70% in 2007 and 2008 seasons, respectively. The combination had significant effects on TSS % of Anna apple fruit in both seasons. However, the highest TSS% value was obtained from the combination between boric acid at middle concentration (0.05%) and calcium chloride at the higher concentration (0.4 %) in the first season and between the middle concentration of both boric acid (0.05%) and calcium chloride (0.2%) in the second season.

Total Acidity (TA %): Data in Table 5 showed that the spraying with boric acid at the lowest (0.025 %) and the highest (0.1 %) concentrations in the first season and the highest concentration in the second season and calcium chloride at the lowest (0.1 %) and middle (0.2 %) concentrations significantly increased TA% of Anna apple fruit as compared with the control treatment. It is worthy to note that TA % significantly decreased with the middle (0.05 %) & lower (0.025 %) and middle (0.05%) concentrations of boric acid in the 1st and 2 ndseasons, respectively, as well as with the higher (0.4 %) concentration of calcium chloride in both seasons. Results in Table 5 showed that all boric acid and calcium chloride combinations had significant effect and the highest TA % value was obtained by the lower concentration of both calcium chloride (0.1%) and boric acid (0.025 %) in 2007 season and with the middle or higher concentration of calcium chloride with the lower concentration of boric acid in the 2008 season. While, the lowest value was obtained by the middle concentration of both boric acid and calcium chloride, in the two seasons.

Table 6: Effect of foliar application of boric acid and calcium chloride on nitrogen, phosphorous and potassium of Anna apple leaves content in 2007 and 2008 seasons

	Apple leaves content of														
	Nitrogen %					Phosphorous %					Potassium %				
Treatments	Calcium chloride %														
Boric acid %	0.0	0.1	0.2	0.4	Mean	0.0	0.1	0.2	0.4	Mean	0.0	0.1	0.2	0.4	Mean
2007 season															
0.0	1.51	1.64	1.84	2.03	1.76	0.27	0.33	0.25	0.31	0.29	1.09	1.40	1.50	1.20	1.30
0.025	1.68	2.03	1.83	2.10	1.91	0.37	0.31	0.36	0.32	0.34	1.61	1.20	1.27	1.47	1.39
0.05	1.95	2.16	1.88	2.05	2.01	0.35	0.38	0.31	0.25	0.32	1.50	1.55	1.27	1.48	1.45
0.1	1.88	2.05	2.28	1.85	2.01	0.29	0.35	0.37	0.39	0.35	1.64	1.94	1.61	1.95	1.78
Mean	1.75	1.97	1.94	2.01	1.92	0.30	0.36	0.32	0.32	0.33	1.46	1.52	1.41	1.52	1.48
2008 season															
0.0	1.62	1.72	1.92	2.10	1.84	0.29	0.34	0.27	0.34	0.31	1.16	1.50	1.57	1.29	1.38
0.025	1.76	2.09	1.90	2.16	1.98	0.32	0.38	0.37	0.33	0.35	1.70	1.28	1.37	1.57	1.48
0.05	2.05	2.22	1.94	2.09	2.08	0.38	0.39	0.33	0.29	0.35	1.55	1.65	1.34	1.56	1.55
0.1	1.96	2.09	2.34	1.91	2.08	0.31	0.36	0.39	0.41	0.37	1.76	2.00	1.71	2.05	1.88
Mean	1.85	2.03	2.03	2.07	2.06	0.33	0.37	0.34	0.34	0.35	1.54	1.61	1.52	1.62	1.57

	2007 season			2008 season		
LSD 0.05	Ca	B	Ca x B	Ca	B	Ca x B
Nitrogen	0.16	0.16	0.33	0.10	0.10	0.19
Phosphorous	0.02	0.02	0.03	0.02	0.02	0.04
Potassium	0.07	0.07	0.13	0.05	0.05	0.10

Table 7: Effect of foliar application of boric acid and calcium chloride on calcium, magnesium and iron of Anna apple leaves content in 2007 and 2008 seasons

	Apple leaves content of														
	Calcium (%)					Magnesium (%)					Iron (ppm)				
Treatments	Calcium chloride %														
Boric acid %	0.0	0.1	0.2	0.4	Mean	0.0	0.1	0.2	0.4	Mean	0.0	0.1	0.2	0.4	Mean
2007 season															
0.0	1.20	0.96	1.09	1.68	1.23	0.52	0.54	0.60	0.57	0.56	210	288	191	139	207
0.025	1.09	1.83	1.06	1.18	1.29	0.57	0.67	0.52	0.52	0.56	271	171	219	122	195
0.05	1.15	1.17	1.34	1.48	1.28	0.62	0.57	0.58	0.61	0.60	188	187	205	197	194
0.1	1.14	1.23	1.14	1.19	1.18	0.58	0.52	0.49	0.51	0.52	240	181	238	158	204
Mean	1.14	1.30	1.16	1.38	1.25	0.57	0.58	0.55	0.55	0.56	227	207	212	154	200
2008 season															
0.0	1.30	0.99	1.13	1.72	1.29	0.54	0.57	0.63	0.62	0.59	170	290	198	149	202
0.025	1.20	1.90	1.10	1.25	1.36	0.59	0.69	0.55	0.56	0.80	276	179	220	130	276
0.05	1.18	1.26	1.39	1.52	1.34	0.64	0.60	0.62	0.64	0.63	192	192	209	200	198
0.1	1.16	1.29	1.20	1.25	1.23	0.60	0.56	0.53	0.55	0.59	250	190	245	162	212
Mean	1.21	1.36	1.21	1.44	1.31	0.59	0.61	0.58	0.59	0.59	222	213	218	160	203

	2007 season			2008 season		
LSD 0.05	Ca	B	Ca x B	Ca	B	Ca x B
Calcium	0.10	0.10	0.20	0.08	0.08	0.15
Magnesium	0.02	0.02	0.04	0.04	0.04	0.07
Iron	1.30	1.30	2.20	6.50	6.50	13.00

Total Sugars (g/100g Fw): Data in Table 5 showed that the spraying of boric acid or calcium chloride significantly increased the total sugars of apple fruits compared with the control in the two seasons. The total sugars in apple fruits increased with boric acid from 3.75 to 4.35 g and from 3.75to 4.40 g, with calcium chloride from 4.50 to 5.30 g and from 4.75 to 4.93 g and with their combinations from 4.95 to 6.80 g and from 5.38 to 6.90 g per 100 g fresh weight of fruit, comparing with 2.55g and 2.43g in 2007 and 2008 seasons, respectively. The significant improvement in total sugars of fruits was detected due to raising boric acid concentrations, while negligible improvement in total sugars content of fruits was observed due to raising calcium chloride concentrations from 0.2 to 0.4 % in both seasons. Results in Table 5 showed that all combinations had significant positive effects and the combination between the higher concentrations of boric acid (0.1%) and calcium chloride (0.4%) was the best combination that resulted higher increment in total sugars of apple fruits.

Total Anthothyanin (mg/100g Fw): Results in Table 5 indicated that fruit anthothyanin content significantly increased due to boric acid or calcium chloride foliar application, as well as their combinations, in the two seasons. The total antothyanin of Anna apple fruit content was increased from 0.03 to 0.05 with boric acid from 0.04 to 0.08 mg with calcium chloride, in both seasons, as well as due to the combinations of boric acid and calcium chloride from 0.05 to 0.64 mg and from 0.05 to 0.61 mg in 2007 and 2008 season, respectively. The highest values were obtained by the combinations of boric acid (0.1%) and calcium chloride (0.4%), in both seasons.

Effect of Boric Acid and Calcium Chloride Spraying on Leaves Nutrients Content: Data presented in Tables 6,7 and 8 showed the effect of spraying with boric acid and/or calcium chloride as well as their interactions on apple leaves content from macro- and micro – nutrients in 2007 and 2008 seasons.

Macronutrients Content

Effect of Boric Acid: Data in Table 6 showed that nitrogen increased in apple leaves with boric acid from 1.68 to 1.95% and from 1.76 to 2.05%, phosphorous from 0.29 to 0.37 % and from 0.31 to 0.38 %, potassium from 1.50 to 1.64 % and from 1.55 to 1.76 %, magnesium from 0.57-0.62 % in 2007 and 2008 seasons, respectively. It is clear that foliar spraying with boric acid significantly increased the nitrogen, phosphorous, potassium and magnesium concentration of apple leaves (Tables, 6 and 7) in seasons of 2007 and 2008, compared with the control. On the contrary, calcium concentrations of apple leaves did not increase due to foliar spraying of boric acid in both seasons. Moreover, calcium content of apple leaves was significantly deceased in the 2008 season with all concentration of boric acid foliar application as well as with the lower concentration in the 2007 season.

Effect of Calcium Chloride: Data in Tables 6 and 7 showed that calcium chloride significantly increased nitrogen in apple leaves from 1.64 to 2.03 % and 1.72 to 2.10%, phosphorous increased from 0.25 to 0.33and from 0.27 to 0.34 %, potassium from 1.20 to 1.50 and from 1.29 to 1.57 %, calcium from 0.96 to 1.68% and from 0.99 to 1.72 % and magnesium from 0.54 to 0.60% and from 0.57 to 0.63% in 2007 and 2008 seasons, respectively. It is clear that the foliar addition of calcium chloride significantly increased leaf content from nitrogen, phosphorous, potassium, magnesium and calcium in seasons of 2007 and 2008 comparing with the control treatment.On the other hand, it is important to point out that foliar spraying of lower and middle concentrations of calcium chloride did not significantly increase calcium content of apple leaves in both seasons.

Effect of the Combinations: Results in Tables 6 and 7 indicated that nitrogen, phosphorous, potassium; calcium and magnesium concentrations in apple leaves were significantly affected due to the interaction between boric acid and calcium chloride in both seasons. The highest values of nitrogen, phosphorous, calcium and magnesium were obtained from the following interactions: boric acid 0.1 % with calcium chloride 0.2 % for nitrogen, boric acid 0.1 % with calcium chloride of 0.4 % for phosphorous and potassium, 0.1% of boric acid with 0.4% of calcium chloride for potassium and the concentration of boric acid (0.05 %) and calcium chloride (0.4%) for calcium and magnesium in the two growing seasons.

Micronutrients Concentration in Apple Leaves

Effect of Boric Acid: Results given in Tables 7 and 8 indicated that the foliar spraying of boric acid significantly increased the concentrations of iron, manganese, zinc and boron in apple leaves in both seasons as compared with the control treatment. The highest values of iron content was obtained from the lowest concentration of boric acid (0.025 %), while the highest values of manganese and boron content were

Table 8: Effect of foliar application of boric acid and calcium chloride on Manganese, Zinc and Boron of Anna apple leaves content in 2007 and 2008 seasons.

	Apple leaves content of														
	Manganese (ppm)					Zinc (ppm)					Boron (ppm)				
Treatments	Calcium chloride %														
Boric acid %	0.0	0.1	0.2	0.4	Mean	0.0	0.1	0.2	0.4	Mean	0.0	0.1	0.2	0.4	Mean
2007 season															
0.0	37	51	40	44	43	22	25	21	30	25	23	58	56	43	45
0.025	45	49	60	57	53	32	30	26	22	28	49	55	60	52	54
0.05	49	68	71	81	67	35	20	24	27	27	52	37	56	64	52
0.1	62	56	52	40	53	25	30	28	30	28	57	30	28	30	36
Mean	48	56	56	56	54	29	26	25	27	27	45	45	50	47	47
2008 season															
0.0	34	53	45	50	46	24	27	24	33	27	24	60	56	45	46
0.025	47	54	62	60	56	35	32	28	25	30	50	56	62	54	56
0.05	51	72	76	85	71	38	23	28	30	30	53	39	58	66	56
0.1	64	60	56	43	56	28	33	30	34	31	58	70	46	39	51
Mean	49	60	60	60	57	31	29	28	31	30	46	56	54	52	52

	2007 season			2008 season		
LSD 0.05	Ca	B	Ca x B	Ca	B	Ca x B
Manganese	2	2	4	3.3	3.3	6.6
Zinc	1.4	1.4	2.8	2.2	2.2	4.4
Boron	3.4	3.4	6.9	3.2	3.2	6.4

attained from the higher concentration of boric acid (0.1%), in both seasons.While, the middle concentration of boric acid (0.05%) gave the highest zinc content in the two seasons.

Effect of Calcium Chloride: Data presented in Tables 7 and 8 showed that calcium chloride as foliar application significantly increased iron, manganese, zinc and boron concentration of apple leaves in the two growing seasons as compared with the control treatment. On the other hand, the concentrations of iron and boron of leaves were decreased due to raising calcium chloride concentrations as foliar spray in both seasons. The highest values of iron, manganese and boron leaves content resulted from the lowest concentration of calcium chloride spraying (0.1 %), while the highest zinc leaves content resulted from the highest concentration of calcium chloride in both seasons.

Effect of the Combinations: Data in Tables 7 and 8 showed that the interaction between boric acid and calcium chloride significantly increased the concentrations of iron, manganese, zinc and boron of apple leaves in the 2007 and 2008 seasons, comparing with the control. The highest values of these micronutrients were obtained from the higher concentration of calcium chloride (0.4 %) with the higher concentration of boric acid (0.1%) for zinc, the higher concentration of boric acid (0.1%) with the middle concentration of calcium chloride (0.2%) for iron and the middle concentration of boric acid (0.05 %) with the higher concentration of calcium chloride (0.4 %) for manganese in the two seasons and for boron in 2007 season.

Effect of Boric Acid and Calcium Chloride Spraying on Blossom End Rot

Effect on Disease Incidence: Data in Table 9 showed that the foliar application of boric acid and calcium chloride at the tested concentrations significantly reduced the incidence of blossom end rot disease on Anna apple fruits, comparing with the control. The disease incidence ranged from 4.7 to 11.1% with boric acid, from 3.6 to 6.6 % with calcium chloride and from 0.5 to 2.9 % with their combinations, comparing with 18.9% and 17.7% in 2007 and 2008 seasons, respectively (Table 9). Results showed that the percentage values of disease incidence were from

Table 9: Effect of foliar application of boric acid and calcium chloride on incidence and severity of blossom end rot disease of Anna apples in 2007 and 2008 seasons

	Blossom end rot disease									
	Incidence %					Severity %				
Treatments	Calcium chloride %									
Boric acid %	0.0	0.1	0.2	0.4	Mean	0.0	0.1	0.2	0.4	Mean
					2007 season					
0.0	18.9	6.4	5.9	4.4	8.9	36.0	14.0	8.0	7.3	16.3
0.025	10.2	2.9	1.8	1.5	4.1	16.0	13.3	12.7	4.0	11.5
0.05	7.7	2.3	1.6	1.5	3.2	14.0	5.3	4.0	4.0	6.8
0.1	7.4	1.1	1.1	0.7	2.6	12.0	4.0	4.0	2.7	5.7
Mean	11.1	3.2	2.6	2.0	4.7	19.5	9.2	7.2	4.5	10.1
					2008 season					
0.0	17.7	6.6	5.4	3.6	8.3	32.7	14.7	10.7	10.0	17.0
0.025	11.1	2.1	1.6	1.6	4.1	15.3	10.0	9.3	4.0	9.7
0.05	5.3	1.2	1.2	1.0	2.2	15.3	5.3	4.7	4.0	7.3
0.1	4.7	1.2	0.8	0.5	1.8	10.0	4.0	4.0	3.3	5.3
Mean	9.7	2.8	2.3	1.7	4.1	18.3	8.5	7.2	5.3	9.8

		2007 season			2008 season		
L.S.D 0.05		Ca	B	Ca x B	Ca	B	Ca x B
	Incidence	0.7	0.7	1.5	0.8	0.8	1.7
	Severity	1.7	1.7	3.4	1.4	1.4	2.8

7.4, 7.7 and 10.2 % in season of 2007 and 4.7, 5.3 & 11.1% in season of 2008 with boric acid at concentrations of 0.1, 0.05 and 0.025 %. The calcium chloride application reduced the disease incidence to 4.4, 5.9 and 6.4% in 2007 season and to 3.6, 5.4 and 6.6 % in 2008 season at concentrations of 0.4, 0.2 and 0.1%. The percentages of disease incidence with boric acid and calcium chloride combinations were 0.7 to 2.9 % in 2007 season and 0.5 to 2.1 % in 2008 season.Results showed that the disease incidence was decreased with increasing the concentration of both boric acid and calcium chloride single or combined application. The highest reduction of disease incidence was obtained with the combinations of boric acid and calcium chloride, especially at the highest concentrations. The significant differences were observed between treatments during two experimental seasons, while no significant differences were recorded between concentrations of 0.05 and 0.1 % of boric acid.

Effect on Disease Severity: All foliar treatments significantly decreased the disease severity of blossom end rot in Apple fruits (Table, 9). The disease severity were 10.0 to 16.0 % with boric acid, from 7.3 to 14.7 % with calcium chloride and from 2.7 to 13.3 % with their combinations, comparing with 36.0% and 32.7 % in 2007 and 2008 seasons, respectively The percentages of disease severity were 12.0, 14.0 and 16.0 % in 2007 and 10.0, 15.3 and 15.3% in 2008 with boric acid at concentrations of 0.1, 0.05 and 0.025 %, respectively. The treatments of calcium chloride gave the disease severity 7.3, 8.0 and 14.0 % in 2007 season and 10.0, 10.7 and 14.7 % in 2008 season at concentrations of 0.4, 0.2 and 0.1 %, respectively. The combination treatments gave the lowest disease severity ranged from 2.7 to 13.3% and 3.3 to 10.0% in 2007 and 2008 seasons, respectively. Data revealed that the efficacy of foliar fertilizations in reducing the disease severity took the same trend of controlling the disease incidence results. No significant differences were noticed between concentrations of 0.2 and 0.4 % of calcium chloride in two seasons and between concentrations of 0.025 and 0.05 % boric acid in 2008 season.

Correlation Coefficient: The correlation coefficient between nutrients concentrations of apple leaves and disease incidence and severity of blossom end rot

Table 10: Correlation coefficient between nutrients contents in apple leaves and incidence or severity of blossom end rot disease (average of the two seasons)

Nutrients content in apple leaves	Correlation coefficient	
	Incidence	Severity
Nitrogen	- 0.5479 **	- 0.5440**
Phosphorous	- 0.4275**	- 0.2824 (NS)
Potassium	- 0.3157(NS)	- 0.4316**
Calcium	- 0.1553 (NS)	- 0.1085 (NS)
Magnesium	- 0.112 (NS)	- 0.1190 (NS)
iron	0.3460*	0.3241*
Manganese	- 0.4752**	- 0.4356**
Zinc	- 0.0460 (NS)	0.0898 (NS)
Bome	-0.4722**	- 0.4321**

(NS) = Non significant *, ** = significant at the probability levels of 0.05 and 0.01, respectively. r 0.05 = 0.289 r 0.01 = 0.372

disease, as average of the two seasons (Table, 10). Results indicated that the disease incidence and severity negatively correlated with macro- and micronutrients concentrations in apple leaves, with the exception of iron concentration.In addition, the highly significantly negative correlation was found between the content of leaves from nitrogen, phosphorous, manganese and boron and the percentage of blossom end rot incidence.Also, highly significant negative correlation was found between nitrogen, potassium, manganese and boron of leaves content and the percentage of blossom end rot severity. In addition, significantly positive correlation was found between leaves iron content and both of incidences and severity percentages of blossom end rot disease. The negatively values correlation of calcium, magnesium and zinc with incidence and severity of blossom end rot disease did not reach to the levels of significance, as well as phosphorous with disease severity and potassium with disease incidence.

DISCUSSION

The results of soil testing show that the experimental soils had high pH and low organic matter content which led to low micronutrients and phosphorus availability [7,31]. Moreover, soil was poor in their available content of micronutrients such as boron and macronutrients such as calcium, measured by the critical levels according to Ankerman and Large [32]. Results revealed that the average of apple fruits yield / tree, number of fruits / tree, fruit weight as well as most of studied fruit physical and chemical characters were improved by spraying with boric acid. The beneficial effects of boron may be due to physiological role in plants. Where, Boron facilitates transport of carbohydrates through cell membrane i.e starch and sugars [9].Also; boron deficient plants suffer from poor translocation or movement of sugar out the leaves. Parr and Laughman [33] postulated that boron is involved in a number of metabolic pathways, i.e sugar transport, respiration, carbohydrate, RNA, IAA and phenol metabolism. The increase in fruit setting percentage which reflected by increasing number of fruits/tree may be attributed due to that boron play an important role as an activator for many enzymes which promote plant growth and flower production [9], pollen germination for successful fruit set and in formation of feeder roots.Our results, except fruit firmness, are in agreement with those obtained by Shorrocks and Nicholson [8] and Dong *et al.* [34]. They reported that boron application was correlated with increasing of fruits size and decreased fruit firmness. Also the obtained results are in harmony with that obtained by Wojcik and Szwonek [4] and Peryea *et al.* [5]. Preharvest Ca treatments used to increase the calcium content of the cell walls of fruit tissue after harvest. Moreover, it is effective in delaying senescence, resulting in firmer, higher Quality fruit [35].

The sprays of calcium chloride significantly increased the average fruit weight, number of fruit / tree, fruit yield /tree and led to improve studied fruit physiological and chemical characteristics as well as nutrients content of apple leaves. The beneficial effect of calcium chloride could be attributed to the physiological role of calcium which plays a binding role in the complex polysaccharides and proteins forming the cell wall [36, 37]. The reduction in pre-harvest fruit dropping due to calcium sprays surely reflected on improving the yield [6,10,38]. The improvement of apple fruits by sprays of calcium may be due to that calcium has stimulating effect on development of root hairs and entire root that are resistant to root decay and cell division [37]. Our results are in agreement with those recorded by Ahmed *et al.* [38] and Casero *et al.* [39]. They reported that the enhancement occurred in fruit quality due to foliar application of calcium could be attributed to the effect of calcium in enhancing and advancing flowering, maturity and the translocation of carbohydrates from leaves to fruits. Results indicated that the role of boron in improving nutrients content of apple leaves related with reducing incidence and severity of blossom end rot disease. Our results revealed significant increase of apple leaves

nutrient content, except iron and calcium.These results are in agreement with those recorded by Hafez & Haggag [6], Donald *et al.* [9] and Wojcik [10].They mentioned that boron promoted more nutrients uptake and assimilation. These results are supported by the findings recorded by El-Shazly *et al.* [40]. Results about improvement of the nutrient status of apple tree leaves could give an explanation for the improvement occurred in resistance to the blossom end rot disease, which was emphasized by the highly significant negative correlation of most nutrients in leaves and the percentage values of incidence and severity of disease.

CONCLUSION

From the Previous Results it Could Be Concluded That: Boron and calcium foliar spray is necessary and important for Anna apple trees grown on boron and calcium deficient soil. Foliar spraying with boric acid at concentration of 0.1 % or calcium chloride at concentration of 0.4 % and their combination twice, the first after petal fall (3 rd week of March) and the second after fruit set (3 rd week of April), significantly increased yield, yield attributes and improved fruit physical and chemicals quality of Anna apple as well as improved leaves nutrients content and clearly decreased the percentage of incidence and severity of blossom end rot disease.

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