Response of "Anna" Apple Trees to Foliar Application of some Mineral Nutrients

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Abstract: This investigation was conducted during 2013 and 2014 seasons on "Anna" apple trees (*Malus domestica* L.). The trees were 5 years old at the start of experiment, budded on Malus rootstock and grown on sandy loam soil in the orchard of El-Nubaria Horticulture Research Station, Behera Governorate. Treatments sprayed with the specified solutions till run off on trees at full bloom stage at which 80% of flower buds reached the stage of full open and one month after fruit setting. The experiment involved the following treatments: control (spraying with tap water), 0.1%, 0.2% and 0.3% Ca chelated, 1%, 2% and 3% K_2SO_4, 0.1%, 0.2% and 0.3% $ZnSO_4$, 0.1%, 0.2% and 0.3% H_3BO_3. Data indicated that increasing foliar application of different nutrients concentration increased shoot length, shoot thickness, leaf area, initial fruit set and final fruit % and decreased fruit drop% as compared with control in both experimental seasons. Furthermore, data showed that, 2%, 3% K_2SO_4 and yield weight/ feddan (ton) significantly increased with H_3BO_3 application up to 3% in both seasons, while 0.1%, 0.2% Ca chelated and 0.1% $ZnSO_4$ treatments gave the lowest values regardless control treatment in both seasons. Moreover, increasing rates of foliar application of all nutrients treatments increased the content of fruits from TSS % and Vit. C content in fruits in, while it was noticed that, all foliar application of K and B treatments decreased acidity and Vit. C content of "Anna" apple fruits. The application of Ca and Zn did not affect on sugar contents and anthocyanin, while increased starch contents in "Anna" apple fruits. Also, foliar application of K and H_3BO_3 treatments increased the sugar contents, while decreased starch contents. Applied of Ca chelated led to increase the Ca %, Mg %, Mn and Cu, while decrease K, Fe and B but not affected on N in the leaf. Also, application of K tended to increase N, P, K, Mg %, Fe, Zn, Mn and Cu in the leaf. The application of B as well as Zn and affected on K, Ca and Mg % in the leaf.

Keywords: Apple, mineral nutrients, fruit quality, yield.

Introduction

Apple is one of the genera of pome fruit trees of the temperate zones belonging to the Rosaceae family and is one of the most important garden crops and due to its high adaptability it is considered as one of the most extensively fruit trees cultivated in temperate zones. Therefore, to improve its quality, modern feeding procedures such as spraying and manure ditch should be employed to ensure reaching of target nutrient in appropriate level to the target site i.e. the fruit. Plant nutrients are taken up both by roots and by upper plant parts (Mengel, 2002). Foliar analysis is widely used to determine the nutrition of perennial fruit crops (Cline, 1990).The macronutrients (nitrogen, phosphorus, potassium, calcium and magnesium) are required in relatively high amounts for crop growth (Conway *et al.,* 2002). Lack of potassium (potash) will cause the leaves to have a grey or dull brown cast towards the edges resembling a scorching (tip burning). Fruit will be small, poorly colored and they may hang on after leaf fall. Calcium gives apples their firmness and crispness. Leaves may also have brown spots in the middle and terminal leaves will be small, yellowish and cupped upwards with dead edges or tips. Between nutrients calcium plays an important role in providing stability and mechanical

strength to the cell structure of the fruit. Thus, the deficiency of calcium in the fruit leads to weakening of middle lamella due to which cells expand and burst (Amiri *et al*., 2008). Zinc application on 'McIntosh' apple seedlings doubled the amount of shoot growth when Zn sulfate ($ZnSO_4$) or a Zn chelate was foliar applied (Neilsen and Hogue, 1983). Yield will be greatly reduced by severe deficiency, and the fruit can be small and misshapen. Calcium and Zn deficiencies are very common in the Egypt tree fruit industry. Boron is an essential micronutrient for trees. When it is not present in sufficient quantity, apple and pear profits are reduced. Boron applications increase fruit set in 'Stayman' apple and Italian prune (Mengel, 2002). Boron sprays after bloom increased fruit set and apple yield (Ebel *et al*., 2000). But, Wojcik (2004) in another study reported that boron used as foliar application had no effect on fruit texture firmness, concentration of soluble solids and blushing of apple fruit and indicated that foliar application of boron and zinc has no effect on yield, SST and ATT of apple fruits. Moreover, many investigations studied the effect of spraying macro and micronutrients on growth, yield and fruit quality such as nitrogen, phosphorus, potassium and magnesium (Amiri *et al*., 2008). However boron; manganese were highly effective in improving, nutritional status yield and quality of different pear and apple trees (Keren, 1996 and Wojcik, 2004).

The purpose of this study was to investigate using foliar application of potassium, calcium, zinc and boron applied in different times on 'Anna" apple vegetative growth, fruit set and drop, yield, fruit quality and mineral contents of leaves and fruits.

Materials and Methods

This investigation was conducted during 2013 and 2014 seasons on "Anna" apple trees (*Malus domestica* L.). The trees were 5 years old at the start of experiment, budded on Malus rootstock and grown on sandy loam soil in the orchard of El-Nubaria Horticulture Research Station, Behera Governorate. Sixty five trees as uniform as possible were selected for achieving this study. The trees were planted at 5 x 5 m apart. Trees were of normal growth, uniform in vigour and received normal fertilization and cultural practices as scheduled in the farm. Treatments sprayed with the specified solutions till run off on trees at full bloom stage at which 80% of flower buds reached the stage of full open and one month after fruit setting. A fine mist ensured complete coverage of fruits before runoff**.** The experiment involved the following treatments: Control (Spraying with tap water), 0.1%, 0.2%, 0.3% Ca chelated, 1%, 2%, 3% potassium sulphate (K_2SO_4), 0.1%, 0.2%, 0.3% zinc sulphate ($ZnSO_4$), 0.1%, 0.2% and 0.3% boric acid (H_3BO_3). The design was a randomized complete block with 5 single-tree replicates and 13 treatments with 2 time intervals of spray all treatments. Foliar sprays were applied using a hand pressure sprayer. Each treatment was surrounded with two rows as guard trees. The effect of the previous treatments was studied by evaluating their influence on the following parameters:

Vegetative growth:

Shoot length (cm): in the spring of each season, 20 non –fruiting shoots of spring cycle were tagged at constant height and at all direction of each tree. At late May, the average length of tagged shoots was measured.

Shoot thickness: at late May in both seasons, shoot thickness for twenty shoots was measured by hand caliber.

Leaf area (cm^2): leaf area was examined during the late of May on fully developed mature leaves (20 leaves) by portable area meter LI-COR model LI-3000A No. PAM 1671 (Bioletti, 1938).

Fruit set and fruit drop:

Both number of flowers and set fruitlets on the tagged branches were counted and recorded for all treatments. Then percentage of fruit set was calculated by the following equation according to Westwood (1978).

$$\%\ \text{Fruit set} = \frac{\text{Number of set fruitlets}}{\text{Number of opended flowers}} \times 100$$

Furthermore, number of dropped fruits were recorded till harvest time, then estimated as percentage on the basis of initial number of fruitlets according to this equation:

$$\%\ \text{Fruit drop} = \frac{\text{Number of dropped fruitlets}}{\text{Number of set fruitlets}} \times 100$$

Yield and yield components:

The produced fruit yield on each replicate tree resulting from the applied treatments was expressed as number of fruits/tree and weight of fruits in kg/ tree which was attained at harvest stage (mid May).

Average fruit weight (g/ fruit): fruit samples were weighted and the average fruit weight for each replicate was calculated.

No. fruits/tree and weight of fruits/tree: at harvest time, yield of each treatment was recorded as yield weight/tree by the multiplying number of fruits × average weight of fruit.

Yield (ton/feddan) was expressed by multiply the weight of fruits/tree x number of trees/feddan.

Fruit firmness: was expressed as (pound / $Inch^2$) according to (Magness and Taylor, 1982). Flesh firmness was measured in two opposite sides of the fruit using magness Taylor pressure tester.

Total soluble solids of fruit juice (TSS %): was used to determine the percentage of TSS by hand refractometer according to Chen and Mellenthin (1981).

The percentage of total acidity: was determined as in fruit juice was measured according to Chen and Mellenthin (1981). Five milliliters from the obtained juice were used to determine the titratable acidity. The titratable acidity was expressed as grams malic acid / 100 milliliters fruit juice.

TSS/ acid ratio: were calculated for each replicate of the applied treatments.

Vitamin C (Ascorbic acid): determined by titration with 2, 6 dichloro phenol-indo-phenol (A.O.A.C., 1985) and calculated as milli-grams per 100 ml of juice.

Total sugars: were determined in fresh fruit samples according to Malik and Singh (1980). Sugars were extracted from 5 gram fresh weight and determined by phenol sulfuric and Nelson arsenate –molybadate colorimetric methods for total and reducing sugars, respectively.

Starch contents: were determined in 0.1 g of the residue by hydrolysis with concentrated HCl for 3 h under reflux condenser (A.O.A C., 1985). The total

reducing power was determined according to the method of Malik and Singh (1980) and the factor 0.9 was used to calculate the starch (Woodman, 1941).

Anthocyanin content (mg/100g): was determined at the stage of coloration (mg/100g fresh weight) according to Rabino *et al*. (1977).

Leaf mineral compositions:

At the end of May of both seasons, samples of 30 leaves /tree were taken at random from the previously tagged shoots, the leaf samples were washed with tap water and distilled water, and then oven dried at 70°C to constant weight and then ground. To determine the leaf mineral contents, ground material of each sample was digested with H_2SO_4 and H_2O_2 according to Wolf (1982). In the digested material, total nitrogen was determined colorimetrically according to Evenhuis and De waard (1976) and phosphorus was determined colorimetrically according to Murphy and Riley (1962), respectively and potassium was determined by flame photometer as described by Cheng and Bray (1951). Calcium, magnesium and micronutrients (Fe, Zn, Cu and Mn) leaf contents were determined by Perkin Elmer atomic absorption Spectrophotometer according to Carter (1993). Boron was determined colorimetrically by the carmine method according to Hatcher and Wilcox (1950). The concentrations of N, P, K, Ca and Mg were expressed as percent, while those of Fe, Zn, Cu, B and Mn were expressed as parts per million, on dry weight basis.

Results of the measured parameters were subjected to computerized statistical analysis using MSTAT package for analysis of variance (ANOVA) and means of treatments were compared using LSD at 0.05 according to Snedecor and Cochran (1990).

Results and Discussion

Vegetative growth:

The data for both experimental seasons for the effect of applying different rates of nutrient concentrations on shoot length of "Anna" apple trees during 2013 and 2014 seasons are presented in Table (1). Data indicated that increasing foliar application of different nutrient concentration increased shoot length as compared with control in both seasons. Generally, control treatment gave the lowest values of shoot length, while spraying 3% K_2SO_4 significantly increased shoot length values compared to the other of foliar application of different nutrient concentrations in both seasons. Furthermore, the effect of applying different rates of K_2SO_4 gave significantly shoot length of "Anna" apple trees for both seasons as compared with another treatments at all concentrations. In general, increasing foliar application of Ca chelated, $ZnSO_4$ and H_3BO_3 from 0.1% to 0.3% and K_2SO_4 from 1% to 3% gave the best results for shoot length in both seasons.

Regarding shoot thickness, the data clearly indicated that all foliar application of different chemical understudies significantly increased the shoot thickness of "Anna" apple trees in two seasons as compared with control treatment. Generally the data revealed that 3% K_2SO_4 treatment recorded the highest values of shoot thickness, while application of 0.1% H_3BO_3 treatment gave the lowest values in both seasons, regardless the control treatment.

As for leaf area, generally, control treatment gave the lowest values of leaf area, while spraying Ca chelated caused increasing in leaf area, leaf area significantly increased as chelated rate increased. Furthermore, the effect of

applying different rates of K_2SO_4, $ZnSO_4$ and H_3BO_3 on the leaf area, data showed that, for both seasons, increasing concentrations from 1% to 3% for K_2SO_4 or 0.1 to 0.3% for $ZnSO_4$ and H3BO3 increased leaf area as compared with control.

The same results were reported by several authors, El-Shazly and Dris (2004) on 'Anna' apple trees grown on sandy calcareous soil found that foliar sprays of chelated Fe, Mn and Zn alone or in a combination increased vegetative growth (shoot length and leaf area) as compared with the control and a positive relationship between increasing the micronutrient rates and vegetative growth, but the differences between the high and medium rates were insignificant in most cases. Also, Ahmed *et al*. (2006) on Anna Apple showed that all applied H_3BO_3 concentrations increased leaf area of trees because H_3BO_3 stimulate cell division as well as the acceleration on the formation of organic foods and the movement of IAA. Moreover, Mansour *et al*. (2008) mention that foliar application of NPK, Zn, Fe and Mn either singly or in combinations with S, B or citric acid significantly were responsible for stimulating the leaf area of "Le-conte" pear trees compared with the control. The promoting effect of NPK, Zn, Fe and Mn on the leaf area might be attributed to their important role in encouraging photosynthesis and chlorophyll formation as well as producing more carbohydrates and amino acids which aid in the formation of new cells. The stimulation effect of B and S on cell division as well as the acceleration on the formation of organic foods and the movement of IAA could explain the present results. Also, Nagwa A. Abdel-Megeed (2012) found that, the application of potassium at different levels as soil application (at 0.5, 1.0 and 1.5 kg/tree) or foliar application (at 0.5, 1.0 and 1.5%) on "Cannino" apricot increased shoot length, leaf area and fruit set and the superior treatment was the highest level of potassium at both foliar and soil application. Wally *et al*. (2012) studied the effect of zinc and urea foliar spray on growth of "Canino" apricot cv. They found that spraying zinc significantly improvd the shoot length, leaf area and fruit set. Samia *et al*. (2013) reported that, foliar applications of micronutrients on "Le conte" pear trees increased shoot diameter, leaf area and fruit set, while decreased fruit drop.

Table (1). Effect of foliar application with different nutrients rates on some morphological parameters of "Anna" apple trees in 2013 and 2014 seasons.

Treatments	Shoot length (cm)		Shoot Thickness (cm)		Leaf area (cm^2)	
	2013	2014	2013	2014	2013	2014
Control	34.78 g	35.23 f	0.63 i	0.65 j	23.56 h	24.05 i
0.1%Ca chelated	35.82 f	36.09 f	0.67 h	0.69 i	24.34 g	24.74 h
0.2% Ca chelated	37.07 e	37.59 e	0.73 ef	0.75 fgh	27.04 de	27.57 ef
0.3% Ca chelated	39.08 d	39.53 d	0.79 c	0.81 cd	30.20 bc	30.89 cd
1% K_2So_4	39.06 d	39.51 d	0.75 de	0.77 ef	26.71 e	27.08 f
2% K_2So_4	42.07 b	42.38 b	0.84 b	0.87 b	30.84 b	31.43 bc
3% K_2So_4	45.18 a	45.85 a	0.92 a	0.95 a	35.68 a	36.29 a
0.1% $ZnSo_4$	35.65 fg	35.80 f	0.71 fg	0.73 h	25.12 f	25.42 g
0.2% $ZnSo_4$	37.27 e	37.58 e	0.75 de	0.76 fg	27.57 d	27.90 e
0.3% $ZnSo_4$	40.17 c	40.36 cd	0.81 bc	0.83 c	30.00 c	30.68 d
0.1% H_3BO_3	35.41 fg	35.95 f	0.68 gh	0.69 i	23.73 gh	24.43 hi
0.2% H_3BO_3	36.98 e	37.11 e	0.73 ef	0.74 gh	26.78 e	27.40 ef
0.3% H_3BO_3	39.26 d	39.83 d	0.78 cd	0.80 de	30.44 bc	31.21 bcd

Means not sharing the same letter(s) within each column for each are significantly different at 0.05 level of probability.

Fruit set and drop percentages:

Data in Table (2) revealed that, for the initial fruit set%, spraying the trees with 0.1 to 0.3% Ca chelated, 1% to 3% K_2SO_4 and (0.1 to 0.3%) $ZnSO_4$ or H_3BO_3 treatments significantly increased initial fruit set percentage as compared with control treatment in both growing seasons. Furthermore, the data revealed that foliar application with K_2SO_4 gave the highest values of initial fruit set percentages $ZnSO_4$ treatments while the values of initial fruit set percentages.

The data concerning the effect of application different rates of nutrient concentrations on the percentage of final fruit set in "Anna" apple trees during 2013 and 2014 seasons showed that, spraying the trees with 1% to 3% K_2SO_4 treatments increased final fruit set percentage significantly as compared with control treatment and other foliar application treatments in both growing seasons. The data concerning the effect of H_3BO_3 application at 0.3% significantly increased the percentage of final fruit set in "Anna" apple trees as compared with control or H_3BO_3 at 0.1 as well as 0.2% in both seasons. Also, spraying $ZnSO_4$ as well as Ca chelated markedly increased final fruit set % as compared with control in both seasons. It was noticed that, no significant differences were found among 0.1%, 0.2% Ca chelated and control treatments on the percentage of final fruit set in "Anna" apple trees during both seasons. Generally, it was noticed application treatments especially 3% K_2SO_4 and 0.3% H_3BO_3 led to increasing final fruit set percentages (Table 2).

Concerning fruit drop%**,** the K_2SO_4 as well as H_3BO_3 treatments gave less values of drop of fruits, while control and Ca chelated treatments gave higher values of fruit drop in both seasons. Also, it was noticed that all concentrations of Ca chelated, K_2SO_4, $ZnSO_4$ or H_3BO_3 treatments decreased significantly the percentage of fruit drop in "Anna" apple trees in 2013 and 2014 seasons as compared control treatment**.** Sandhu *et al*. (2010) investigated the influence of foliar and soil application of zinc sulphate on growth and nutrient status of own-rooted sand pear (*Pyrus pyrifolia*. They found that, all application treatments increased fruit set and decreased fruit drop percentages. Also, Nagwa A. Abdel-Megeed (2012) found that, the application of potassium at different levels as soil application (at 0.5, 1.0 and 1.5 kg/tree) or foliar application (at 0.5, 1.0 and 1.5%) on "Cannino" apricot increased fruit set and the superior treatment was the highest level of potassium at both foliar and soil application. Wally *et al*. (2012) studied the effect of zinc and urea foliar spray on growth of "Canino" apricot cv. They found that spraying zinc significantly improvd fruit set. Furthermore, Samia *et al*. (2013) reported that, foliar applications of micronutrients on "Le conte" pear trees increased fruit set, while decreased fruit drop.

Table (2). Effect of foliar application with different nutrients rates on intial and final fruit set and drop % of "Anna" apple trees in 2013 and 2014 seasons.

Treatments	Initial fruit set %		Final fruit set %		Fruit drop %	
	2013	2014	2013	2014	2013	2014
Control	56.76 i	57.96 h	12.16 h	12.77 hi	81.21 a	80.77 a
0.1%Ca chelated	62.88 fg	63.27 ef	12.20 h	12.45 i	79.07 b	79.15 ab
0.2% Ca chelated	64.24 f	64.48 e	12.96 gh	13.66 gh	78.07 b	78.01 b
0.3% Ca chelated	67.54 e	67.64 d	13.61 fg	14.42 fg	76.19 cd	76.19 d
1% K_2So_4	73.44 cd	73.67 c	19.29 c	19.64 c	71.37 e	72.29 f
2% K_2So_4	75.86 ab	76.79 ab	21.24 b	22.02 b	66.19 g	65.82 h
3% K_2So_4	77.77 a	78.21 a	23.48 a	24.18 a	63.88 h	63.75 i
0.1% $ZnSo_4$	60.07 h	60.05 g	12.96 gh	13.26 hi	76.80 cd	77.91 c
0.2% $ZnSo_4$	61.68 gh	62.01 fg	15.00 e	15.65 e	75.33 cd	74.81 e
0.3% $ZnSo_4$	64.03 f	64.55 e	16.23 d	17.41 d	74.54 d	73.85 ef
0.1% H_3BO_3	68.49 e	68.73 d	14.14 ef	15.12 ef	75.11 cd	74.76 e
0.2% H_3BO_3	72.75 d	73.26 c	17.03 d	17.79 d	68.09 f	68.11 g
0.3% H_3BO_3	74.90 bc	75.43 bc	23.21 a	23.67 a	65.94 g	65.54 h

Means not sharing the same letter(s) within each column for each are significantly different at 0.05 level of probability.

Yield and yield components:

Results in Table (3) revealed that all treatments increased average fruit weight as compared with control treatments in both seasons, and this increasing in fruit weight is big enough to be significant for all foliar application except 0.1% Ca chelated treatment as compared with control treatments. The data also showed that K_2SO_4 treatments gave the best results as for average weight of fruit, followed by H_3BO_3, Ca chelated and finally $ZnSO_4$ treatments in both seasons.

Also, data showed that 0.3% H_3BO_3 significantly increased the number of fruits per tree in first season, while 3% K_2SO_4 in second season as compared with control treatment. In addition, spraying "Anna" apple trees during 2013 and 2014 seasons with Ca chelated and $ZnSO_4$, data indicated that, all rates of two nutrients understudy caused an increase in number of fruits per tree as compared with control in both seasons and the differences mostly not significant. On the other hand, data revealed that, foliar application of "Anna" apple trees with Ca chelated with 0.1% to 0.3% as well as 0.1 H_3BO_3 treatments did not affect significantly on the average number of fruits per tree in both seasons comparing control treatment**.**

Concerning the influence of applying different rates of nutrients on weight of fruits/tree (kg) of "Anna" apple trees in 2013 and 2014 seasons, results generally revealed that all applied treatments gradually increased weight of fruits/tree (kg) as compared with control treatment in both seasons.

Furthermore, data showed that, 2%, 3% K_2SO_4 and 0.3% H_3BO_3 treatments applied caused significantly increased yield weight/feddan (ton) in both seasons, while 0.1%, 0.2% Ca chelated and 0.1% $ZnSO_4$ treatments gave the lowest values regardless control treatment in both seasons.

Mansour *et al*. (2008) noticed that, yield of Le- Conte pear trees was positively affected by foliar application of NPK, Zn, Fe and Mn either alone or in combinations with S, B or citric acid. Adding citric acid B, or S to NPK, Zn, Fe and Mn solutions, in descending order was favourable in improving the yield. Ben Mimoun *et al*. (2009) found that no effect was observed on fruit yield on either peach or plum. The same results were obtained by Hassan *et al*. (2010) on “Hollywood” plum trees.

Regarding the influence of different mineral spraying of "Anna" apple trees on fruit firmness (pound /inch^2) during the both seasons, data in Table (3)

showed that, Ca chelated at 0.2 as well as 0.3% treatments significantly increased the firmness of fruits as compared with other spraying nutrients and control treatment. Meanwhile, foliar application of H_3BO_3 caused a little decrease in fruit firmness (pound /inch^2) of "Anna" apple trees during the both seasons and this decrease was not significant. At the same time, foliar application of different rates of K_2SO_4 and $ZnSO_4$ did not caused any effects on fruit firmness as compared with control treatment in both seasons. Khalifa *et al*. (2009) on Anna apple trees, found that increasing B concentration increased fruit firmness. Also, Nagwa A. Abdel-Megeed and Wally (2007) on "Le Conte" pear trees found the same results. Also, chelated calcium increased fruit firmness as compared with control.

Table (3): Effect of foliar application with different nutrients rates on some yield parameters of " Anna" apple trees in 2013 and 2014 seasons.

Treatments	Average fruit weight (g)		No fruits/ Tree		Weight of fruits/tree (Kg)		Yield weight/ feddan Ton		Fruit firmness (pound /inch^2)	
	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014
Control	110.67 g	113.28 g	265.33 e	273.67 e	29.36 f	31 e	4.93 g	5.21 e	12.53 cd	12.7 cd
0.1%Ca chelated	113.83 g	115.91 g	265.67 e	269 e	30.24 ef	31.21 e	5.08 fg	5.24 e	13.30 bc	13.56 bc
0.2%Ca chelated	128.03 de	130.93 de	267.33 e	274 e	34.22 de	35.87 cde	5.75 efg	6.03 de	14.20 ab	14.40 ab
0.3%Ca chelated	133.87 d	135.57 d	271.00 e	276.67 e	36.27 d	37.51 cd	6.09 de	6.30 cd	14.60 a	14.92 a
1% K_2So_4	144.97 c	147.99 c	374.00 b	384 b	54.19 b	56.82 b	9.10 bc	9.55 b	12.17 d	12.06 d
2% K_2So_4	168.97 a	173.06 a	412.00 a	415. 67 a	69.58 a	71.93 a	11.69 a	12.09 a	12.07 d	11.84 d
3% K_2So_4	174.30 a	177.87 a	414.67 a	422.33 a	72.26 a	75.10 a	12.08 a	12.62 a	11.70 d	11.82 d
0.1% $ZnSo_4$	114.73 fd	117.02 fg	273.67 e	282.67 e	31.40 ef	33.07 de	5.28 efg	5.57 de	12.20 d	12.10 d
0.2% $ZnSo_4$	117.70 fg	120.08 fg	306.00 d	317 d	36.01 d	38.07 cd	6.05 de	6.4 cd	12.37 cd	12.37 d
0.3% $ZnSo_4$	123.80 ef	125.47 ef	327.00 c	335.33 c	40.48 c	42.07 c	6.80 d	7.07 c	12.23 d	12.13 d
0.1% H_3BO_3	135.90 d	137.35 d	264.67 e	273.33 e	35.97 d	37.54 cd	6.04 de	6.31cd	12.20 d	12.06 d
0.2% H_3BO_3	156.47 b	159.3 b	335.00 c	340.33 c	52.4 b	54.22 b	8.81 c	9.11 b	12.10 d	11.85 d
0.3% H_3BO_3	170.47 a	173.5 a	417.00 a	421.33 a	71.0 a	73.09 a	11.94 a	12.28 a	12.00 d	11.75 d

Means not sharing the same letter(s) within each column for each are significantly different at 0.05 level of probability.

Chemical fruit characteristics:

Results of the effects of different mineral spraying of "Anna" apple trees on some chemical fruit characteristics during 2013 and 2014 seasons are illustrated in Tables (4 and 5).

Total soluble solids (TSS %):

The data revealed that increasing rates of foliar application of all nutrients gradually increased the content of fruits from TSS % in both seasons, except spraying Ca chelated. At the same time, foliar application of 2%, 3% K_2SO_4 0.2% and 0.3% H_3BO_3 tended to gave the highest values of TSS % in "Anna" apple fruits significantly as compared with all other treatments in both seasons. Generally, 3% K_2SO_4 treatment gave the best results as for TSS % as compared with all treatments. The increment of TSS % as a result of spraying B may be due to the fact that B is know to increase transportion of sugars and increase of carbohydrate movement from leaves into fruit tissue (Dugger, 1983). Wojcik and Wojcik (2003) on conference pear trees, reported that increasing B concentration increased fruit content of TSS. Moreover, Nagwa A. Abdel-Megeed and Wally (2007) on "Le-conte" pear trees sprayed with H_3BO_3 at 0.1% and 0.2% found that, all treatments increased TSS as compared to the control.

Total acidity (%):

Data showed that all Ca chelated concentrations increased acidity % as compared with control but this increased did not big enough to be significant.

Decreasing acidity % as a result of foliar application of K_2SO_4 as well as H_3BO_3 may be due the effect of K and B in increasing the formation and translocation of sugars. Furthermore, the application of Ca did not caused any effects on acidity % in fruits of "Anna" apple as compared with control treatment in both seasons. Similar results were previously registered by Calouro *et al.* (2008) in pear found that, total soluble solids were significantly correlated with fruit phosphorus, potassium and zinc contents, whereas titratable acidity was significantly correlated with fruit potassium. Regarding the firmness of the pulp, no significant correlations were found.

TSS/ acid ratio:

The data showed that, 3% K_2SO_4 treatment gave the highest value of TSS/ acid ratio of "Anna" apple fruits during both seasons followed by 2% K_2SO_4 and 0.3% H_3BO_3 treatments. Also, it was noticed that, all foliar application of Zn, K and treatments sharply increased TSS/ acid ratio of "Anna" apple fruits during both seasons, while foliar application of Ca chelated gradually decreased TSS/ acid ratio as compared with control treatment in both seasons. The same trend was previously reported by Erdem and Öztürk (2012) on pear found that, Mn sprays had positive significant effects on the aril/peel ratio, TSS, juice content of arils, anthocyanin index. Furthermore, Albion (2013) reported that, four sprays of Metalosate Potassium during the last 6 weeks before 'Jonagold' apple harvest improved color and soluble solids concentration in fruits. In potassium-sufficient 'Jonagold' apple orchards, sprays of Metalosate Potassium before harvest may be recommended for improvement in fruit appearance and taste. These results confirm that Metalosate Calcium is effective at reducing bitter pit. Also, they confirm that Metalosate Potassium is effective at increasing soluble solids content as well as improving fruit color.

Vitamin C (mg/ 100 ml juice):

The data as for the effects of different rates of nutrient concentrations on Vit. C (mg/100 ml juice) content in "Anna" apple fruits during 2013 and 2014 seasons showed that, increasing rates of Ca chelated as foliar application gradually led to increasing Vit. C (mg/100 ml juice) content significantly in "Anna" apple fruits as compared with all remainder and control treatments in both seasons. Meanwhile, applied of different H_3BO_3 rates as foliar application on significantly decreased Vit. C (mg/100 ml juice) content in both seasons as compared with control. Also, it was noticed that, 02% and 0.3% $ZnSO_4$ treatments gradually decreased Vit. C (mg/100 ml juice) content in "Anna" apple fruits as compared 0.1% $ZnSO_4$ in both seasons.

These results about the chemical constituents of apple fruits related to foliar applied some nutrients are in parallel with those obtained by Keshavarz, *et al*. (2011) using B and Zn on nuts, Wally *et al*. (2012) on apricot, Asgharzade *et al.* (2012) on apple, Erdem and Öztürk (2012) on three different pear cultivars, Nagwa Abd El-Megeed (2012) on "Canino" apricot, Albion (2013) on 'Jonagold' apple and Samia *et al*. (2013) on "Le conte" pear trees.

It can be concluded that, increasing rates of foliar application of all nutrients, except Ca chelated treatments increased the content of fruits from TSS %, acidity and Vit. C content in fruits, while it was noticed that, all foliar application of B treatments decreased Vit. C content of "Anna" apple fruits.

Total Sugars (%):

As for sugar contents in "Anna" apple fruits as affected to spraying with different nutrients data in Table (5) revealed that, as for the effects of Ca chelated and $ZnSO_4$ on total sugars (%), the application of Ca or Zn did not affect significantly on total sugars %, while foliar application of K_2SO_4 and H_3BO_3 treatments significantly increased the total sugars % in fruits as comparison with control treatment in both seasons. These findings agreed with those previously reported by Eric and Williams (1986) on pear, and Khalifa *et al*. (2009) on Anna apple fruits, they reported that increasing B concentration increased sugars in fruits. Also, Asgharzade *et al.* (2012) found that, Brix index of apple fruits was affected by calcium borate and micronutrients spray. The same results reported by Nagwa Abd El-Megeed (2012) found that, the application of potassium at different levels as soil application (at 0.5, 1.0 and 1.5 kg/tree) or foliar application (at 0.5, 1.0 and 1.5%) on "Canino" apricot increased total sugars as compared with control. Also, Samia *et al*. (2013) reported that, foliar applications of micronutrients on "Le conte" pear trees increased TSS and acidity, while decreased total sugar.

Starch contents (%):

Data in Table (5) illustrated the effects of different concentrations of minerals on the percentage of starch in "Anna" apple fruits during 2013 and 2014 seasons, showed that all Ca chelated concentrations significantly increased starch % as compared with control in both seasons. Data as for the effects of different concentrations of K, Zn and H_3BO_3 treatments on the percentage of starch showed that all concentrations significantly decreased starch % as compared with control. Decreasing starch % as a result of foliar application of K, Zn and H_3BO_3 may be due the effects on increasing the formation and translocation of sugars. These results are in parelle with those obtained by Asgharzade *et al.* (2012) on apple and Erdem and Öztürk (2012) on some pear cultivars.

Anthocyanin contents (mg/ 100 g):

The data as for the effects of different rates of nutrient concentrations on anthocynin (mg /100 g) content in "Anna" apple fruits during 2013 and 2014 seasons showed that, increasing rates of K and B as foliar application gradually led to increasing content of anthocynin (mg /100 g) significantly in "Anna" apple fruits as compared with all remainder and control treatments in both seasons. Meanwhile, applied of different rates of Ca chelated as well as Zn as foliar application did not affect significantly on anthocynin (mg /100 g) content in both seasons as compared with control.

It can be concluded from the previous results that, the application of Ca and Zn did not affect on sugar contents and anthocyanin, while increased starch contents in "Anna" apple fruits. Also, foliar application of K and H_3BO_3 treatments increased the sugar contents, while decreased starch contents.

Table (4): Effect of foliar application with different nutrients rates on some chemical fruit characteristics of "Anna" apple trees in 2013 and 2014 seasons.

Treatments	TSS %		Acidity %		TSS/acid ratio		Vitamin C (mg/100 ml juice)	
	2013	2014	2013	2014	2013	2014	2013	2014
Control	11.10 j	11.15 i	0.56 b	0.58 c	19.54 h	19.04 f	21.17 e	22.02 e
0.1%Ca chelated	11.30 i	11.47 h	0.61 a	0.59 bc	18.64 i	19.45 f	26.15 b	26.69 c
0.2% Ca chelated	11.23 i	11.27 hi	0.61 a	0.62 ab	18.32 i	18.18 g	26.73 b	27.89 b
0.3% Ca chelated	11.00 j	11.10 i	0.63 a	0.64 a	17.47 j	17.34 h	28.29 a	29.87 a
1% K_2So_4	13.37 d	13.57 d	0.46 cd	0.44 efg	29.37 d	31.09 c	21.27 e	20.44 g
2% K_2So_4	14.03 b	14.23 b	0.43 d	0.42 fg	32.48 b	34.19 b	20.95 ef	20.04 g
3% K_2So_4	14.47 a	14.63 a	0.35 e	0.36 h	41.89 a	40.32 a	19.90 f	19.58 g
0.1% $ZnSo_4$	11.63 h	11.73 g	0.49 c	0.48 d	23.75 g	24.62 e	23.51 c	23.98 d
0.2% $ZnSo_4$	12.13 g	12.27 f	0.47 c	0.45 def	26.00 ef	27.26 d	22.17 d	23.19 d
0.3% $ZnSo_4$	12.27 f	12.37 f	0.47 c	0.46 de	25.96 f	26.89 d	21.38 de	22.10 e
0.1% H_3BO_3	12.90 e	13.00 e	0.49 c	0.48 d	26.53 e	27.3 d	21.28 e	21.91 f
0.2% H_3BO_3	13.67 c	13.9 c	0.46 cd	0.45 def	29.51 d	31.13 c	20.40 ef	20.26 g
0.3% H_3BO_3	14.00 b	14.13 b	0.45 cd	0.41g	31.37 c	34.48 b	19.87 f	19.51 g

Means not sharing the same letter(s) within each column for each are significantly different at 0.05 level of probability.

Table (5): Effect of foliar application with different nutrients rates on total sugars starch and anthocyanin contents of "Anna" apple fruits in 2013 and 2014 seasons

Treatments	Total sugars (%)		Starch (%)		Anthocynin (mg / 100 g)	
	2013	2014	2013	2014	2013	2014
Control	7.50 de	7.63 d	3.16 c	3.32 c	19.54 e	19.59 f
0.1%Ca chelated	7.57 de	7.67 d	3.17 c	3.19 d	19.40 e	19.14 f
0.2%Ca chelated	7.37 ef	7.43 de	3.33 b	3.42 b	19.34 e	19.02 g
0.3%Ca chelated	7.10 f	7.13 e	3.50 a	3.68 a	19.21 e	18.68 g
1% K_2So_4	7.90 c	8.07 c	2.83 e	2.74 f	22.11 c	22.83 d
2% K_2So_4	8.20 b	8.47 b	2.66 f	2.52 h	24.13 b	24.72 b
3% K_2So_4	8.67 a	8.80 a	2.39 g	2.25 i	26.91 a	27.62 a
0.1% $ZnSo_4$	7.57 de	7.70 d	2.99 d	2.97 e	19.54 e	19.77 f
0.2% $ZnSo_4$	7.60 de	7.70 d	2.95 d	2.89 e	19.36 e	19.87 f
0.3% $ZnSo_4$	7.73 cd	7.90 c	2.98 d	2.90 e	20.09 d	20.65 e
0.1% H_3BO_3	7.60 de	7.70 d	2.90 d	2.83 f	20.39 d	21.14 e
0.2% H_3BO_3	7.77 cd	7.93c	2.71 e	2.72 fg	21.40 c	22.84 d
0.3% H_3BO_3	8.00 bc	8.23 b	2.66 f	2.62 gh	21.95 c	23.65 c

Means not sharing the same letter(s) within each column for each are significantly different at 0.05 level of probability.

Leaf mineral contents:

Concerning the effects of different concentrations of nutrients on leaf macro and micro-nutrients in "Anna" apple trees during 2013 and 2014 seasons data are shown in Tables (6 and 7).

N (%):

It was obvious from the obtained results that, 3% K_2SO_4 and 0.3% H_3BO_3 treatments in both seasons increased N percentage in "Anna" apple leaf as compared with all other treatments. Moreover, the results showed that, the usage of different nutrients such as Ca, Zn, K and B in different rates enhanced N percentage in leaf in both seasons as compared with control except 0.1% Ca chelated. It can be concluded that, the spraying trees with K as well as B significantly increased N percentage in "Anna" apple leaf in the first and the second seasons, as compared with the other treatments. The data are in line with El Seginy and Khalil (2000) on Le-conte pear, found that Urea plus GA_3 treatments significantly increased leaf (N) content, while, Khalifa *et al*., (2009) on Anna apple trees, found that increasing boron concentration increased leaf nitrogen. Also, Sandhu *et al*. (2010) on pear, found that increasing in the nitrogen and potassium status of zinc treated trees but no definite trend was observed in phosphorus level. Furthermore, Shahin *et al*. (2010) on “Anna”

Apple trees, Zavalloni *et al*. (2011) on apple, Erdem and Öztürk (2012) on pear, Nagwa Abd El-Megeed (2012) on apricot and Samia *et al*. (2013) on "Le conte" pear trees found the same trend.

P (%):

Concerning P, data cleared that, the usage of 1% K_2SO_4 increased significantly P percentage in "Anna" apple leaf in the first season more than all treatments. Furthermore, the treatments of 0.2% and 0.3% $ZnSO_4$ gave an increment in P percentage in apple leaf in both seasons. Also it was noticed that, spraying trees with different rates of H_3BO_3 did not enhancing P percentage in "Anna" apple leaf in both experimental seasons. These results are not going in line with those previously by Wojcik and Wojcik (2003) on conference pear tree reported that B application did not affect leaf phosphorus content. Also, Mansour *et al*. (2008) found that spraying all nutrients with or without citric acid was significantly very effective in enhancing percentages of P in the leaves of "Le-conte" pear as compared with the check treatments.

K (%):

The effects of different concentrations of different treatments on K, the data revealed that, applying all concentrations of K appeared to have the most important role in improving K percentage in "Anna" apple leaf in the two seasons. At the same time, all Ca chelated spraying on the trees reduced K percentage in "Anna" apple leaf in the two seasons and this reduction in K content will not big enough to significant, but application of Zn as well as B treatments did not affected on K percentage in "Anna" apple leaf in the two seasons. These results are not in line with those obtained by Khalifa *et al*. (2009) on Anna apple trees they reported that increasing B rates increased leaf K content. On the other side, Wojcik and Wojcik (2003) on conference pear tree reported that B application did not affect leaf K content. Hassan *et al*. (2010) on “Hollywood” plum trees, found that, Gibberellins or Aminofert alone or in combination (GA_3 + Aminofert or GA_3 + a mixture of chelated “Fe, Zn, and Mn”) applied to foliage caused a pronounced increase in leaf K content.

Ca (%):

Regarding to Ca, data in showed that, the highest value of Ca percentage in "Anna" apple leaf was in case of Ca chelated treatments which showed significantly results, while B applied as H_3BO_3 foliar application showed a reduction in Ca % in "Anna" apple leaf in both seasons. It was noticed from the data that 0.3% Ca chelated significantly increased Ca percentage in "Anna" apple leaf in both seasons as compared with all remainder treatments. Furthermore, the applied of Zn as well as K nutrients did not affected on Ca percentage in "Anna" apple leaf. In this respect, Neilsen and Neilsen (2002) in apple trees and Wojcik and Wojcik (2003) reported that spraying B before full bloom or after harvest increased leaf Calcium content.

Mg %:

As for Mg, data demonstrated that, all K and Ca chelated concentrations as well as 0.1 % zinc sulphate treatments recorded the highest values of Mg percentage in "Anna" apple leaf in both seasons, while 0.2%, 0.3% Zn rates and all concentrations of H_3BO_3 recorded the lowest values. Results also showed that, 0.2 and 0.3% Ca chelated treatments gave a highest significant increasing in Mg percentage in "Anna" apple leaf in both seasons. Ben Mimoun *et al*. (2004) on pistachio tree found that, K fertilization increased leaf potassium concentration with no effect observed on Mg leaf contents. Also, Erdem and Öztürk (2012) found that, foliar Zn application changes in Mg concentration and not significant. Nagwa Abd El-Megeed (2012) found that, the application of potassium at different levels as soil application (at 0.5, 1.0 and 1.5 kg/tree) or foliar application (at 0.5, 1.0 and 1.5%) on "Canino" apricot increased significantly Mg% in leaves as compared to control.

It can be concluded from the above data that, applied of Ca chelated led to increase the Ca and Mg percentage, while decrease K and did not affected on N in the leaf. Also, application of K tended to increase N, P, K and Mg % in the leaf. The application of B as well as Zn did not affected on K, Ca and Mg % in the leaf.

Fe ppm (mg/L):

The obtained results showed that, the usage of K, Zn and B in both seasons increased Fe in "Anna" apple leaves as compared with the usage of Ca chelated and control treatments. Moreover, the treatments with different Ca chelated rates tend to decrease Fe content in "Anna" apple leaves in both seasons. It was noticed that, spraying trees with 0.3% K_2SO_4 as well as 0.3% $ZnSO_4$ gave higher values of Fe content in "Anna" apple leaves in both seasons. Furthermore, the differences among the treatments of 0.1 % Ca chelated and control treatment, in one hand and between 0.2 % and 0.3 % H_3BO_3, on the other, were not enough to be significant in Fe in the two seasons in "Anna" apple leaves.

Zn ppm (mg/L):

Regarding to Zn, data demonstrated that, the usage of 0.3% $ZnSO_4$ increased and gave the highest increment in Zn content in "Anna" apple leaf more than all treatments. Also, the Zn ppm was high with Ca chelated and B treatments in both seasons as compared with control treatment. On the other hand, K spraying on the trees as potassium sulphate with different rates led to decrease insignificant the Zn content in "Anna" apple leaf in both seasons. Furthermore, the differences among the treatments of different rates of K as well as B were not significant, while significant differences were found among different rates of Zn in both seasons in Zn content of "Anna" apple leaf. On the opposite side, No significant differences among the treatments of 0.1% and 0.2% Ca chelated in Zn percentage in both experimental seasons.

Mn ppm (mg/L):

Concerning Mn, data found in Table (7) revealed that, 0.3% Ca chelated, 3% potassium sulphate and 0.3% zinc sulphate gave the highest values for Mn in "Anna" apple leaf in the two seasons more than other treatments and no significant differences were found among these treatments. Generally, all

applied foliar sprays of nutrients led to increase and significantly Mn in "Anna" apple leaf as compared with control in the two seasons.

Regarding leaf Fe, Zn and Mn contents, similar results were previously registered by Wojcik and Wojcik (2003) and Khalifa *et al.* (2009) on Anna apple trees. In this respect, Hassan *et al*. (2010) on “Hollywood” plum trees, found that, Gibberellins or Aminofert alone or in combination (GA_3 + Aminofert or GA_3 + a mixture of chelated “Fe, Zn, and Mn”) applied to foliage caused an increase in micro-nutrient concentrations (Fe, Zn, and Mn) in all treatments comparing to the control. Also, application of Aminofert at 0.25% + GA_3 at 20 ppm was more effective compared to other treatments in the two seasons.

Cu ppm (mg/L):

The data as for Cu in leaf, data in Table (7) cleared that, 0.2% and 0.3% Ca chelated increased the Cu content in "Anna" apple leaf in the two seasons, while 0.1% Ca chelated did not appear any effect. Also, 1% K treatment was the most effective treatment in increasing Cu ppm in "Anna" apple leaf in both seasons, while 2% and 3% K did not increased Cu in "Anna" apple leaf in the two seasons. Applied 0.2% and 0.3% Zn as well as 0.2% and 0.3% B also increased Cu content in "Anna" apple leaf in both seasons, while 0.1% Zn and 0.1% B did not increased Cu in "Anna" apple leaf in the two seasons. Furthermore, data revealed that, 0.3% B gave the highest value for Cu in leaves in the two seasons more than other treatments. No significant differences were noticed among the treatments of control, 0.1% Ca and 2% K in Cu ppm in the leaves in the two seasons.

B ppm (mg/L):

Results for B illustrated in the Table (7) cleared that, all Ca chelated treatments tend to decrease B content in "Anna" apple leaf in both seasons, while, the usage of different rates of K as well as Zn treatments tend to increase B in the two seasons. Additionally, all B treatments especially 0.3% treatment gave the highest and significant values of B in "Anna" apple leaf in both seasons. On the other side, no significant differences were observed among the treatments of control, 0.1% Ca chelated and 0.1% Zn treatments in B ppm in both seasons.

These finding were in line with those found by Nagwa A. Abd El-Megeed and Wally (2007) on "Le-conte" pear trees sprayed with H_3BO_3 at 0.1% and 0.2% found that, all treatments increased both leaf and fruit boron content as compared to the control. The same conclusion was reported by Mansour *et al*. (2008) on "Le-conte" pear trees and Khalifa *et al*. (2009) on Anna apple trees found that increasing B concentration increased leaf boron content. Also, Hassan *et al*. (2010) on “Hollywood” plum trees and Stino *et al*. (2010) on Florida Prince Peaches reported that, Fe, Zn, B and Mn was increased in all treatments comparing to the control. On conference pear trees in Poland, Wojcik and Wojcik (2003) found that foliar B before full bloom or after harvest increased B concentration in leaves. Also, El-Shazly and Dris (2004) on ‘Anna’ apple trees found that, foliar sprays of Fe increased leaf Ca, Mg and Fe contents and decreased leaf N, P, K, Mn and Zn contents as compared with the control. Also, Sandhu *et al*. (2010) on pear found that Zn applied led to increase the level of zinc in the foliage. There was also an increase in Fe, Mn and Cu content of foliage after the application of zinc sulphate either through soil or

foliar application. Moreover, Shahin *et al*. (2010) studied the effect of Fertifol Misr (N, P, K, Mg, Zn, Fe, Mu, Cu, Mo & B) and gibberellic acid on leaf chemical composition on “Anna”. Results showed that, leaf minerals contents were positively affected by single or combined application of Fertifol Misr and gibberellic acid compared to unspraying. Asgharzade *et al.* (2012) found that, concentration of nutrient such as B and Ca were increased with use of micronutrients and calcium borate as a foliar application method. Also, Nagwa Abd El-Megeed (2012) found that, the application of potassium at different levels as soil application (at 0.5, 1.0 and 1.5 kg/tree) or foliar application (at 0.5, 1.0 and 1.5%) on "Canino" apricot found that, all potassium treatments did not give clear trend for leaf content of Fe, Zn and Mn. Moreover, Samia *et al*. (2013) reported that, foliar applications of micronutrients on "Le conte" pear trees increased Fe, Mn, Zn, Cu and B contents in leaves with increasing the rates of micronutrients application.

In conclusion, our results generally showed that, applied of Ca chelated and potassium sulphate led to increase the Mn and Cu, while the first decrease Fe and B and the second decreased Zn contents in the leaf. Also, application of zinc sulphate and H_3BO_3 tended to increase Fe, Zn, Mn and Cu in the leaf.

Table (6): Effect of foliar application with different nutrients rates on some leaf macronutrients of "Anna" apple trees in 2013 and 2014 seasons.

Treatments	N (%)		P (%)		K (%)		Ca (%)		Mg (%)	
	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014
Control	1.85 h	1.87 e	0.31 cde	0.30 cd	1.71 d	1.71 de	1.22 de	1.25 d	0.69 e	0.70 d
0.1%Ca chelated	1.86 gh	1.87 e	0.32 cd	0.33 bc	1.68 ef	1.68 ef	1.27 c	1.28 c	0.71 c	0.72 c
0.2%Ca chelated	1.88 f	1.89 de	0.32 cd	0.34 ab	1.67 f	1.65 f	1.35 b	1.36 b	0.73 a	0.74 b
0.3%Ca chelated	1.90 e	1.91 cd	0.31 cde	0.29 d	1.67 f	1.65 f	1.42 a	1.45 a	0.73 a	0.76 a
1% K_2So_4	1.92 d	1.93 c	0.37 a	0.31 bcd	1.80 c	1.81 c	1.23 d	1.21 fg	0.71 c	0.70 d
2% K_2So_4	1.95 bc	1.96 b	0.32 cd	0.31 bcd	1.86 b	1.89 b	1.22 de	1.18 g	0.71 c	0.70 d
3% K_2So_4	1.98 a	2.01 a	0.32 cd	0.30 cd	1.97 a	2.02 a	1.23 d	1.18 g	0.72 b	0.72 c
0.1% $ZnSo_4$	1.88 f	1.89 de	0.33 bc	0.32 bcd	1.70 de	1.71 de	1.23 d	1.24 de	0.70 d	0.69 de
0.2% $ZnSo_4$	1.90 e	1.92 cd	0.35 ab	0.34 ab	1.71 d	1.72 d	1.23 d	1.24 de	0.70 d	0.68 e
0.3% $ZnSo_4$	1.92 d	1.93 c	0.37 a	0.37 a	1.69 def	1.69 de	1.23 d	1.24 de	0.68 f	0.66 e
0.1% H_3BO_3	1.91 de	1.93 c	0.29 e	0.29 d	1.71 d	1.72 d	1.21 de	1.22 ef	0.68 f	0.69 f
0.2% H_3BO_3	1.94 c	1.96 b	0.30 de	0.30 cd	1.71 d	1.71 de	1.19 e	1.18 g	0.66 g	0.66 de
0.3% H_3BO_3	1.96 b	1.97 b	0.31 cde	0.32 bcd	1.70 de	1.69 de	1.15 f	1.25 d	0.66 g	0.64 g

Means not sharing the same letter(s) within each column for each are significantly different at 0.05 level of probability.

Table (7): Effect of foliar application with different nutrients rates on some leaf micronutrients of "Anna" apple trees in 2013 and 2014 seasons.

Treatments	Fe (ppm)		Zn (ppm)		Mn (ppm)		Cu (ppm)		B (ppm)	
	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014
Control	120.00 ef	122.67 ef	20.67 de	22.00 fg	43.00 e	44.00 g	10.00 e	10.67 d	74.00 g	75.33 gh
0.1%Ca chelated	120.00 ef	121.33 fg	24.67 c	26.00 de	47.33 cd	48.67 def	10.00 e	9.00 e	74.67 fg	75.33 gh
0.2%Ca chelated	118.33 fg	120.00 g	26.67 bc	27.67 cd	50 b	53.33 bc	11.00 cd	11.33 d	71.67 h	73.33 h
0.3%Ca chelated	116.67 g	117.33 h	27.67 b	29.00 bc	55.33 a	57.00 a	12.33 b	13.33 b	69.00 i	70 i
1% K_2So_4	124.33 c	125.67 cd	20.00 e	19.67 gh	47.33 cd	48.33 ef	11.33 cd	11.33 d	76.33 ef	77.67 ef
2% K_2So_4	127.33 ab	129 b	21 de	22 fg	51.33 b	54 b	10 e	9.67 e	78.33 cd	80 cd
3% K_2So_4	129.00 a	132.33 a	19.00 e	18.33 h	55.33 a	57.00 a	10.67 de	9.00 e	79.33 c	81 cd
0.1% $ZnSo_4$	122.33 cd	123.67 def	25.00 c	26.00 de	46.00 d	47.00 f	10.67 de	9.67 e	75.33 efg	76.33 fg
0.2% $ZnSo_4$	125.33 bc	127.00 bc	29.00 b	30.67 b	49.00 bc	50.67 cde	11.67 bc	13b c	76.67 de	77.67 ef
0.3% $ZnSo_4$	128.33 a	129.00 b	32.67 a	34.00 a	55.67 a	57.67 a	11 cd	12.33 c	78.33 cd	79 de
0.1% H_3BO_3	121.33 de	122.33 efg	21.00 de	22.00 fg	45.33 de	46 fg	10.67 de	11 d	79.33 c	82 c
0.2% H_3BO_3	123.33 cd	124.33 de	22.67 d	23.67 ef	47.00 cd	48.00 ef	12.33 b	13.33 b	86.00 b	87 b
0.3% H_3BO_3	125 bc	125.67 cd	22.67 d	24.67 e	50.00 b	51.33 bcd	14.00 a	15.33 a	91.67 a	96.33 a

Means not sharing the same letter(s) within each column for each are significantly different at 0.05 level of probability.

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الملخص العربي

استجابة أشجار التفاح "آنا" للرش الورقي ببعض العناصر المعدنية

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طالب دراسات عليا (وافد عراقى)

اجريت هذه الدراسة خلال موسمي ٢٠١٣ و ٢٠١٤ على أشجار التفاح صنف آنا عمرها خمس سنوات ومطعومة على أصل المالص ومنزرعة في أرض لومية رملية في محطة بحوث البساتين بالنوبارية محافظة البحيرة. تم رش الأشجار بمحلول العناصر الغذائية مرتين الأولى عند إزهار ٨٠% والثانية بعد شهر من عقد الثمار. وكانت المعاملات هي: مقارنة (رش بماء الحنفية) ٠,١ ، ٠,٢ و ٠,٣ % كالسيوم مخلبي، ١، ٢ ،٣% كبريتات بوتاسيوم، ٠,١، ٠,٢ ،٠,٣% من كل من كبريتات الزنك وحمض البوريك. وقد أشارت النتائج إلى أن زيادة معدلات الرش بالعناصر المختلفة أدى الى زيادة كل من طول وسمك النموات الخضرية والمساحة الورقية والنسبة المئوية للعقد الابتدائي والنهائي بينما قللت من النسبة المئوية لتساقط الثمار بالمقارنة بمعاملة المقارنة خلال موسمي الدراسة. أيضا اتضح ان المعاملات ٢ و ٣% كبريتات بوتاسيوم و ٠,٣%حمض بوريك تسببت في زيادة معنوية في وزن المحصول بالطن للفدان في كلا موسمي الدراسة بينما المعاملات ٠,١، ٠,٢% كالسيوم مخلبى و ٠,١% كبريتات زنك أعطت أقل النتائج بغض النظر عن معاملة المقارنة. أيضا لوحظ ان زيادة معدلات الرش بالعناصر أدت إلى زيادة في محتوى الثمار من المواد الصلبة الكلية وفيتامين ج. بينما لوحظ أن كل معاملات البوتاسيوم و حمض البوريك قللت من محتوى الثمار من الحموضة و فيتامين ج. وقد اتضح أن إضافة الكالسيوم والزنك لم تؤثر على محتوى السكر والأنثوسيانين بينما تزيد محتوى الثمار من النشا. أيضا لوحظ أن إضافة البوتاسيوم وحمض البوريك أدت إلى زيادة محتوى الثمار من السكر وقللت النشا. وقد وجد أن إضافة الكالسيوم المخلبى أدت إلى زيادة في محتوى الأوراق من الكالسيوم والماغنسيوم والمنجنيز والنحاس بينما خفضت البوتاسيوم والحديد والبورون ولم تؤثر على محتوى النتروجين في الأوراق. أيضا لوحظ أن إضافة البوتاسيوم أدت إلى زيادة محتوى الأوراق من النتروجين والفوسفور والبوتاسيوم والماغنسيوم والحديد والزنك والمنجنيز والنحاس، كما لوحظ أن إضافة البورون والزنك لم تؤثر على محتوى الأوراق من البوتاسيوم والكالسيوم والماغنسيوم.