Response of Anna Apple Trees to Number and Time of Boron and Zinc Foliar Application

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ABSTRACT

The present study was conducted in the growing seasons 2000-2001 and 2001-2002. Anna apple trees were sprayed at different dates and number with borax at concentration of 200 ppm and zinc sulphate at concentration of 0.3% separate or in combinations with each other. Spraying dates were as follow: after harvest (at the end of September of 2000 and 2001), before full bloom and at full bloom of both seasons. The effect on tree growth, leaf mineral contents, fruit set, yield , fruit quality and storability were investigated. Spraying boron alone once (AH or BFB) or spraying zinc alone twice (AH + BFB) or (AH + AFB) and three times (AH, BFB and AFB) had a great effect on fruit set, yield and fruit quality and storability. However, leaf N, K and Fe was not affected by any of the B and Zn sprays. Moreover, a great effect of the combined Zn and B sprays were obtained. In general, the double and triple sprays of zinc with one boron spray AH or BFB were the most effective treatments on tree growth, fruit set, fruit retention, yield, fruit quality and storability.

INTRODUCTION

Boron and zinc are of the important nutrients for the growth and productivity of apple trees. Anna apple is the most commercially planted cultivar in Egypt. Accordinally, investigations on the different aspects of applying B and Zn nutrients are needed. Low boron levels have been found to restrict the proportion of flowers setting fruits and decrease yield in a number of trees crop species (Nyomora *et al.*, 1997). Increases in pollen germination rate (de Wet *et al.*, 1989), fruit yield (Hanson, 1991) and fruit quality (Svagzdys, 1995) have occurred in response to foliar B applications. This suggests that there is a specific requirements for B in the reproductive process of fruit tree. Zinc is a cofactor for RNA-polymerase , thus it is critical for protein synthesis (Faust, 1989). It is also involved in the formation of tryptophan, a precursor to IAA (Marschner, 1986) which can be a limiting factor in vascular tissue differentiation. Because of the rapid conversion of zinc to an unavailable form (Westwood, 1995) especially in the calcareous soil, soil application of such element is not always effective. Time and number of foliar applications and the optimum concentration of both nutrients are believed to be influencing factors. Zinc and boron were mentioned to be sprayed separately or together to dormant trees immediately after harvest or as fall spray + dormant spray (Westwood, 1995). The best time and number of boron and zinc sprays of apple tress had been investigated. Nyomora *et al.* (1997) stated that fall leaf B application increased fruit set and yield of almond. However, Stover et al, 1999

reported that pre-bloom Zn and B foliar sprays increased cropping of Empire apple. Additionally, B sprays after full bloom increased fruit set and yield of apple trees (Wojcik *et al.*, 1997). However, Zude *et al.*(1998) found that B concentration in the fruit and the fruit storability of Elstar apples were increased by summer B sprays. Maksoud and Haggag (1996) found that the yield of the following year was increased when B was applied between harvest and leaf fall. Accordingly, the present study was undertaken to characterize fruit set, fruit retention, yield, fruit quality and storability of Anna apples under various B and Zn spraying dates (after harvest, before full bloom and at full bloom) and number of applications.

MATERIALS AND METHODS

The present study was conducted in an orchard at Abou El-matameer in Behera governorate in 2000 - 2001 and 2001 - 2002 seasons. Seven years old Anna apple trees (*Malus domestica,* Borkh) on Malus rootstock were grown in a calcareous sandy clay soil. Sixty three trees as uniform as possible with three replicate for each treatment were selected. Trees were sprayed with Zn SO_4 (30% Zn) at a concentration of 0.3% and Borax (17.5 %B) at a concentration of 200 ppm at different dates, either singly or in combination with each other. Each tree received 6 liters of the sprayed solution. Foliar $ZnSO_4$ sprays were as follow:

- No Zn spray (control).
- one spray; at the end of September 2001 and 2002, after harvest (AH), two weeks before full bloom (BFB) or at full bloom (AFB).
- Two sprays; AH + BFB or AH + AFB
- Three sprays; AH + BFB +AFB
- Borax was only sprayed once AH or BFB

Twenty one spraying ZnxB combinations representing seven Zn and three B treatments were used (7x3). Treatments were arranged in a randomized complete block design with three replicates for each treatment, using one tree as a single replicate (21 treatments x 3 replicate = 63 trees).

Tree growth was expressed as number and average length (cm/shoot) of one-year-old shoots per tree. Also, leaf area (cm^2) and the percent of non-opened buds were calculated. Three individual limbs from different parts of each tree were marked in mid February. Fruit set and fruit retention (No. of fruits after set (April) /No. of fruit at harvest (early July) were estimated. The number of fruits was counted on each tree at harvest and yield was presented as weight of fruits per tree.

For nutrient determinations, a leaf sample of 30 leaves from each experimental tree was collected in August (2002 and 2003) from the middle part of the outer shoots. Leaves were washed with tap and distilled water and oven

dried at 70°C to a constant weight. Dried leaves were ground and digested with H2SO4 and H2O2 according to Evenhauis and De Waard (1980) and suitable aliquots were taken for the determination of mineral elements. Nitrogen and phosphorus were colorimetrically determined according to Evenhauis (1976) and Murphy and Riley (1962), respectively. Potassium was measured with a Flame photometer. Ca, Mg, Fe, Mn, Zn and B were measured by Perken Elemer Atomic Absorption Spectrophotometer.

For investigating the effect of the different sprays on fruit quality a sample of 40 mature fruits was taken at random from each tree at harvest of both seasons (2002and 2003). Ten fruits were taken for estimating fruit weight (g), TSS, acidity as malic acid and firmness and fruit breakdown. Also, the content of carbohydrate fractions was determined as follow: the flesh of fruits was cut into small pieces by a clean knife and mixed well by an electric mixer. Five grams of each replicate were dipped in 95% ethyl alcohol for subsequent extraction. Reducing sugars were determined by Nelson's method as illustrated by Malik and Singh (1980). Non-reducing and total sugars were determined by hydrolysis with hydrochloric acid and measured according to Nelson's method. Starch content was also measured after the hydrolysis of 0.1 g of the residue with a concentrated HCL for three hours under reflex condenser (A.O.A.C, 1980). Anthocyanin content was measured according to (Sastry and Tischer, 1952). For storability determinations, the rest of each fruit sample (30 fruits) were stored in open plastic boxes at 0°C and 85-90 % R.H. and after 40 days fruit firmness (Lb/in2) and the percent of fruit break down were estimated. Data were statistically analyzed according to Snedecor and Cochran (1980).

RESULTS AND DISCUSSION

Shoot length

Data in Table 1 showed that, in both seasons, spraying boron alone after harvest (AH) or before full bloom (BFB) increased shoot length as compared with the control (no B spray). However, all Zn sprays (except spraying Zn once either before full bloom or at full bloom) significantly increased shoot length as compared with the control (no Z sprays) in both seasons. A significant interaction effect between Z and B sprays were obtained in both seasons as follow: spraying Zn once (AH) with B (0 , AH or BFB) significantly increased shoot length as compared with the control (No Zn and B sprays). Also, spraying Zn twice (AH + BFB) or twice (AH + AFB) or three times (AH + BFB + AFB) and B (0, AH or BFB) increased shoot length as compared with no B and Zn sprays (Table 1).

Number of shoots per tree

Spraying boron alone either AH or BFB gave a significantly higher shoots number than no B spray in both seasons (Table 1). Additionally, all Zn sprays increased number of shoots per tree (except one Zn spray BFB in the first season) as compared with the control (no Zn spray) in both seasons. Neilsen and Hoyt (1990) reported that dormant and post harvest zinc sprays had beneficial effects on improving apple tree growth. A significant interaction effect was obtained between Zn and B spray. Spraying Zn twice (AH + BFB) or twice (AH + AFB) or three times (AH+ BFB + AFB) with B (0, AH or BFB) significantly increased the number of shoots per tree in both seasons (Table1). Wojcik (1998a) working on plum trees , found that spraying boron before full bloom, at the beginning of flowering, at petal fall and at the end of September increased the number of 1-year old shoots and reduced their mean length. Also, Hansen (1974) reported that number and average length of apple tree shoots were increased by boron supply.

Leaf area

Leaf area was significantly increased by spraying boron either AH or BFB in both seasons (Table 1). A relationship between boron supply , growth and leaf development of apple trees was reported (Hansen, 1974). He found that the best leaf development occurred when leaf boron content reached 30 ppm. Generally, Wojcik and Mika (1996) stated that boron application either before or after flowering increased growth of apple trees. However, all Zn sprays had no significant effect on leaf area in the first season as compared with the control. On the other hand, in the second season leaf area was significantly decreased by spraying Zn twice (AH + BFB), or twice (AH + AFB) or three times (AH+ BFB + AFB) as compared with the non sprayed control. The data in Table 1 also showed a significant interaction effect between Zn and B sprays in both seasons. Zinc sprays once (AFB) or twice (AH + BFB)or twice (AH + AFB) or three times (AH+ BFB + AFB) with one B spray before full bloom significantly increased leaf area as compared with the control (no Zn and B sprays) in both seasons. This might be due to the effect of boron alone. Stover *et al.* (1999) found that apple leaf development was not enhanced and was lower following combined foliar sprays of boron and zinc.

Percent of non opened buds

The number of non opened buds was not significantly affected by any of the boron treatments in both seasons (Table 1). Similar results were obtained by Stover *et al.*(1999). However, all Zn sprays decreased the percent of non opened buds when compared with the control (no Z spray) in both seasons. Additionally. all interacted Zn and B sprays (except for 0 Zn with boron AH in the first season and 0 Zn with boron BFB in both seasons) significantly decreased number of non opened buds as compared with the 0 Zn and B sprayed control In both seasons (Table 1). Hansen (1974) stated that flowering was delayed

and the percentage of dead buds was increased as boron levels reached toxicity in apple trees. Moreover, Kamali and Childers (1970) working on peach, reported that the excess of boron resulted in a decrease in the number of opened buds.

Percent of fruit set

The results obtained in Table 2 showed that both boron sprays dates gave a significantly higher fruit set percent than the non sprayed control in both seasons. Similar results were obtained by BaiJian and XiaoLing (1997) and Wojcik *et al.* (1997) as boron was sprayed at and after full bloom. The increase of fruit set by boron supply in autumn (AH) might be due to the high mobility of the leaf accumulated boron by B foliar sprays (Picchioni *et al.*,1995) and its translocation to the flowers, thus increasing boron concentration in the flower tissue and enhancing fruit set of the following year (Nyomora *et al.*, 1997, Sanchez *et al.*, 1997, WojciK, 1998c and Zude *et al.*, 1998). Additionally, all Zn sprays increased fruit set in both seasons as compared with zero Zn spray. Moreover, a significant interaction effect was obtained by Zn and B sprays in both seasons. Spraying Zn once (AH), twice (AH + BFB), twice (AH + AFB) and three times (AH + BFB + AFB) with one B spray (AH or BFB) significantly increased fruit set percent when compared with the non Zn and B sprayed control in both seasons (Table 2). BaiJian and XiaoLing (1997) found that application of both boron and zinc in early December increased fruit set percentage.

Percent of fruit retention

Spraying boron alone had no significant effect on the number of fruits retained in both seasons. However, the data in Table 2 showed that spraying zinc twice (AH +BFB), twice (AH +AFB) or three times (AH + BFB + AFB) significantly increased fruit retention percent when compared with 0 Zn spray in both seasons. Additionally, spraying Zn twice (AH and +BFB), twice (AH + AFB) with boron sprayed once (AH or BFB) increased fruit retention as compared with no Zn and B sprayed control in both seasons. These results agreed with those of Stover *et al.* (1999). They reported that spraying Zn and boron before bloom increased cropping by increasing the retention of flower buds of apple trees.

Yield (kg/tree)

The yield was significantly increased by both B spraying dates in the first season. In the second season spraying B after harvest only increased yield as compared with the non sprayed control (Table 2). Nyomora *et al.* (1999) working on almond indicated that postharvest foliar boron sprays was more effective in increasing B concentration, fruit set and yield. Wojcik *et al.* (1997) reported that apple trees yield was increased when boron was applied after full bloom. However, Maksoud and Haggag (1996) stated that an increase in yield

was obtained by applying boron between harvest and leaf fall. Moreover, in both season all zinc sprays (except once BFB and once AFB in the second season) significantly increased yield as compared with 0 Zn spray. A significant interaction effect was observed between zinc and boron sprays in both seasons. Boron sprayed once (AH) with zinc sprayed once (AH, BFB or AFB) significantly increased the yield, in both seasons, as compared with 0 Zn B prays (Table 2). Also, boron (0, AH or BFB) with zinc sprayed twice (AH + BFB) or twice (AH + AFB) had a significant effect on yield in both seasons (Table 2). These results are in line with those of Wojcik *et al.* (1997) and Stover *et al.* (1999).

Average fruit weight

The data in Table 2 showed that neither boron nor zinc sprays had a significant effect on fruit weight in both seasons. Moreover, no significant interaction effect between zinc and boron sprays was obtained in both seasons (Table 2). Stover *et al.* (1999) working on apple found that, while cropping was increased by Zn and B sprays, mean fruit weight was less reduced.

Leaf N, P, K and Ca content

The data in Table 3 showed that leaf N and K contents were not significantly affected by spraying boron either AH or BFB in both seasons. However, in both seasons leaf P and Ca were significantly increased by boron spray (AH or BFB)as compared with no B spray. Wojcik (1998b) found no effect of boron sprays on the uptake and distribution of nitrogen within apple trees, meanwhile potassium concentration in spur leaves was increased by after full bloom boron sprays. He also reported that boron sprays after full bloom increased Ca uptake , thus raised Ca concentrations in plant parts. Moreover, all zinc sprays did not affect leaf N, K and Ca as compared with the control (0 Zn spray) in both seasons. On the other hand, leaf P content was decreased, in both seasons, by all zinc sprays (except for one spray BFB in both seasons and one spray AFB in the second season), as compared with the control (0 Zn spray). A significant interaction effect between Zn and B sprays on leaf N and Ca contents were observed in the second season only. No interaction effect on leaf K content was obtained in both seasons (Table 3). However, leaf P was significantly decreased by spraying zinc once (AH), twice (AH + BFB), twice (AH + AFB) or three times (AH+ BFB + AFB) with one boron spray (AH or BFB) in both seasons as compared with the non sprayed control (no Zn and B spray).

Leaf Mg, Fe, Zn , Mn and B content

Spraying boron once after harvest (in both seasons) or after full bloom (in the first season) significantly increased leaf Mg content as compared with the non sprayed control (Table 4). On the contrary, Wojcik (1998b) found that leaf boron application after full bloom reduced plant Mg uptake. Data in Table 4

showed that leaf boron content was significantly increased by both boron sprays (AH and BFB) in both seasons. These data are in line with those of Wojcik and Mika (1996). They found that post harvest boron sprays increased leaf boron content of the following year. However, Wojcik (1998b) reported that boron sprays before Full bloom were less effective in increasing this microelement in plants than leaf application after full bloom. The increase in boron concentration might be due to the high boron uptake characters of the apple leaves. Picchioni *et al.* (1995) working on apple, reported that foliar uptake of boron by shoot leaves was 88-96% complete within 24 hours of application and more than 50% of the B retained on leaf surface was absorbed within 6 hours of application. However, leaf Fe, Zn and Mn content was not affected by the boron spray in both seasons. Additionally, spraying Zn once BFB or twice AH and AFB decreased leaf Mg and B contents in the first season only (Table 4). Neilsen and Hoyt (1990) stated that although zinc deficiency symptoms can be decreased by various dormant and post harvest Zn sprays, residual effect on leaf Zn concentration were slight (Zn sprays had minimal effect on leaf Zn concentration). Leaf Mn content was also decreased by all Zn treatments in both seasons (except one spray BFB or AFB in both seasons and two sprays AH and BFB in the second season only) as compared with the non sprayed control. In general, leaf Zn content was increased by all Zn sprays in both season when compared with zero Zn spray (Table 4). The increase of Zn concentration might be attributed to the limited mobility of foliar applied zinc (Chamel, 1988). Zhang and Brown (1999) attributed the low mobility of foliar applied zinc in pistachio to the high binding capacity of leaf tissue for Zn. Moreover, a significant interaction effect between Zn and B sprays was obtained on leaf Mg, Zn, Mn and boron content, whereas leaf Fe was not affected by any of the Zn and B spraying combinations (Table 4).

TSS and acidity

The data in Table 5 showed a significant increase in TSS and decrease in acidity contents by both B spraying dates as compared with the non sprayed control in both seasons. Similarly, Wojcik (1998a) found that foliar boron sprays in spring or autumn increased the total soluble solids content of plum fruits at harvest. The data also showed that all Zn sprays (except one spray BFB or AFB) increased TSS content in both seasons as compared with 0 Zn spray. However, acidity was decreased by spraying Zn twice (AH + AFB) or three times(AH+ BFB +AFB) only in the second season (Table 5). Similarly, Agaev (1984) found that acidity in grapes was decreased by zinc sprays. Generally, no significant interaction effect on TSS and acidity was obtained in the first season. However, in the second season one Zn spray (AH) with one B spray (AH or BFB) and two Zn sprays (AH + BFB) or (AH + AFB) with one B spray (AH or BFB) significantly increased the TSS content in the second season only. In contrast, acidity was decreased in the second season by one Zn spray (AH) with one B spray (AH or BFB), two Zn sprays (AH + BFB) with BFB boron spray,

two Zn sprays (AH + AFB) with AH or BFB boron spray and three Zn sprays (AH+ BFB + AFB) with AH or BFB boron spray as compared with the non Zn and B sprayed control (Table 5). Stampar *et al.* (1998) working on different apple cultivars, reported that foliar application of boron and zinc increased soluble solids and organic acid contents.

Reducing, non-reducing and total sugars

The data in Table 6 indicated that total and reducing sugars contents were increased by both boron spraying dates in both seasons as compared with non sprayed control. Moreover, non-reducing sugars were significantly increased in the second season only (Table 6). Additionally, all zinc sprays (except one Zn spray BFB or AFB) significantly increased the content of total and reducing sugars in both seasons (Table 6). However, spraying Zn twice (AH + BFB), twice (AH + AFB) or three times (AH+ BFB + AFB) gave higher non - reducing sugars content than the non sprayed control in both seasons (Table 6). A significant interaction effect between Zn and B treatments was obtained. Total and reducing sugars were significantly increased by the following Zn B spraying combinations; (one Zn spray AH with one B spray AH or BFB), (two Zn sprays AH + BFB), (two Zn sprays AH + AFB) and (three Zn sprays AH+BFB+AFB) with zero, AH and BFB boron spray in both seasons (Table 6). Spraying Zn three times (AH +BFB+AFB) with boron one time (AH or BFB) increased non reducing sugars content as compared with the non Zn B sprayed control in both seasons (Table 6).

Starch and anthocyanin

Fruit starch and anthocyanin contents were significantly higher by both boron spraying dates in both seasons than the non sprayed control (Tables 5 and 6). Moreover, spraying Zn twice AH + BFB, twice AH+AFB and three times AH+BFB+AFB significantly increased starch and anthocyanin contents in both seasons. In both seasons spraying Zn and B together resulted in a significant increasing effect on starch and anthocyanin contents when compared with the non treated control as follow; (one Zn spray AH with one B spray BFB), (two Zn sprays AH+BFB with one B spray AH or BFB), (two Zn sprays AH + AFB with one B spray AH or BFB) and (three Zn sprays AH+BFB+AFB) with B (0, AH or BFB) (Table 5).

Firmness

The data in Table 7 indicated that fruit firmness either at harvest or after storage was significantly increased by spraying boron once AH or BFB in both seasons. Wojcik *et al.* (1997 and 1999) sprayed boron after full bloom. They found that apple fruit firmness after storage was increased. The increase in firmness might be related to the increase of fruit calcium content (Wojcik *et al.*, 1997). Leaf Ca that increased by boron sprays in the present study might be an important source of fruit calcium, thus increasing firmness. Zinc sprayed twice

(AH+ BFB), twice (AH+ AFB)or three times (AH+ BFB+ AFB) increased fruit firmness at harvest and after storage in both seasons as compared with zero Zn spray. A significant interaction effect between Zn and B sprays was obtained. In both seasons firmness at harvest was generally increased by Zn and B spraying combinations. In addition, firmness after storage was significantly increased by all Zn B sprays (except for one Zn spray AH, BFB or AFB with zero B spray) in both seasons (Table 7).

Fruit breakdown

Spraying boron once AH or BFB significantly decreased the breakdown at harvest and after storage as compared with no B spray In both seasons (Table 7). All zinc sprays (except one spray BFB or AFB) significantly decreased the breakdown percent at harvest and after storage in both seasons as compared with the control. In general, all boron and zinc combinations decreased fruit breakdown at harvest and after storage. The previous increase in firmness at and after harvest might have a strong effect on decreasing fruit break down. These results are in line with those of Wojcik *et al.* (1997 and 1999). they found that boron foliar sprays after flowering resulted in greater fruit firmness after storage and lower incidences of bitter pit and internal breakdown.

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Table 1. Effect of Zn and B spray dates on trees growth of Anna apple during 2001 and 2002 seasons.

Zn application	Shoot length (cm)				No. of shoots/tree				Leaf area (cm^2)				% of buds not opened			
	B application				B application				B application				B application			
	zero	AH	BFB	Aver.	zero	AH	BFB	Aver.	zero	AH	BFB	Aver.	zero	AH	BFB	Aver.
								2001 season								
Zero	26.0	28.0	29.0	27.67	17.2	19.6	20.2	10.00	29.6	36.8	33.7	33.37	36.7	27.8	30.2	31.57
One spray (AH)*	30.0	31.2	33.7	31.63	20.6	22.2	23.7	22.17	33.5	38.7	42.6	38.27	10.2	8.1	11.3	9.87
One spray (BFB)**	26.2	28.0	30.1	28.10	19.2	20.1	21.4	20.23	30.2	36.5	40.6	35.77	21.3	20.6	18.6	20.16
One spray (AFB)***	25.3	27.8	26.7	26.60	21.2	23.4	23.6	22.73	31.7	40.1	42.7	38.17	23.6	18.3	20.7	20.87
Two sprays (AH+BFB)	31.8	32.7	34.6	33.03	26.4	28.2	30.1	28.23	35.7	39.5	43.6	39.60	6.6	5.2	6.0	5.93
Two sprays (AH+AFB)	34.8	36.5	38.6	36.63	27.2	30.7	31.2	29.70	34.8	40.2	44.6	39.87	7.2	4.3	6.3	5.93
Three sprays (AH+BFB+AFB)	35.7	37.8	38.4	37.30	30.7	33.2	34.6	32.83	36.3	42.8	46.8	41.97	3.3	2.0	2.7	2.67
Average	29.97	31.71	33.01		32.21	25.34	26.40		33.11	39.23	42.09		15.56	12.33	13.69	
$L.S.D_{0.05}$	B	Zn	B x Zn		B	Zn	B x Zn		B	Zn	B x Zn		B	Zn	B x Zn	
	1.41	2.17	3.8		1.79	2.8	4.8		4.23	6.51	11.40		3.80	5.85	10.24	
								2002 season								
Zero	20.6	26.6	28.3	25.17	19.3	22.8	21.7	21.27	31.2	33.5	34.4	33.03	39.7	25.2	36.7	33.87
One spray (AH)*	26.2	29.4	29.2	28.27	26.9	28.4	30.6	28.63	32.4	37.6	39.2	36.40	8.8	8.2	10.2	9.07
One spray (BFB)**	21.2	23.2	25.9	23.43	21.2	27.7	28.4	25.77	30.7	35.8	38.2	34.90	19.6	20.2	20.7	20.17
One spray (AFB)***	22.7	24.7	25.8	24.40	23.6	26.2	26.8	25.53	30.2	36.3	39.8	35.43	21.8	20.4	20.8	21.00
Two sprays (AH+BFB)	28.7	36.2	37.7	34.20	26.3	30.2	32.6	29.70	35.6	39.7	40.9	38.73	9.2	4.0	7.7	6.97
Two sprays (AH+AFB)	30.2	38.6	39.6	36.13	26.0	28.3	34.2	29.50	36.2	40.6	42.7	39.83	8.1	4.3	7.0	6.47
Three sprays (AH+BFB+AFB)	35.6	42.6	45.3	41.17	31.7	36.2	38.7	35.53	40.2	42.7	47.8	43.57	2.6	1.8	1.6	2.00
Average	26.46	31.61	33.11		25.0	28.54	30.42		33.79	38.03	40.43		15.69	12.01	14.96	
$L.S.D_{0.05}$	B	Zn	B x Zn		B	Zn	B x Zn		B	Zn	B x Zn		B	Zn	B x Zn	
	2.0	3.06	5.4		2.6	4.0	7.01		3.08	4.74	8.3		4.06	6.25	1.94	

*AH = One spray after harvest. **BFB = One spray before full bloom. ***AFB = One spray after full bloom.

Table 2. Effect of Zn and B spray dates on fruit set, fruit retention and yield of Anna apple during 2001 and 2 02 seasons.

Zn application	Fruit set (%)				Fruit retention (%)				Yield (kg/tree)				Average fruit weight			
	B application				B application				B application				B application			
	zero	AH	BFB	Aver.	zero	AH	BFB	Aver.	zero	AH	BFB	Aver.	zero	AH	BFB	Aver.
							2001 season									
Zero	18.73	28.31	23.81	23.62	60.9	60.4	62.6	61.3	44	58	48	50	143	140	138	140
One spray (AH)*	26.09	36.72	30.13	30.98	63.7	67.3	64.6	65.2	56	67	58	60	140	146	136	141
One spray (BFB)**	23.71	32.15	30.78	28.88	60.3	64.5	61.7	62.2	50	63	56	56	142	140	146	143
One spray (AFB)***	22.13	34.13	32.18	29.48	61.3	68.6	62.7	64.2	51	67	55	58	140	142	142	141
Two sprays (AH+BFB)	32.76	41.21	36.21	36.73	73.2	78.7	75.3	75.7	58	69	68	65	138	143	140	140
Two sprays (AH+AFB)	35.82	40.35	36.52	37.56	71.7	77.8	74.7	74.7	56	70	70	65	140	146	143	143
Three sprays (AH+BFB+AFB)	36.21	43.13	38.12	39.15	80.5	86.7	80.8	82.7	70	76	71	72	134	148	146	143
Average	27.92	36.57	32.54		67.4	72.0	68.9		55	67	61		140	144	142	
$L.S.D_{0.05}$	B	Zn	B x Zn		B	Zn	B x Zn		B	Zn	B x Zn		B	Zn	B x Zn	
	3.12	4.80	8.42		5.2	8.0	14.0		4	6	11		7	11	19	
							2002 season									
Zero	20.51	30.73	25.62	25.62	61.2	63.2	62.2	62.2	49	67	54	57	140	141	141	141
One spray (AH)*	30.72	38.91	34.05	34.56	66.7	70.6	66.8	68.0	68	71	66	68	140	145	143	143
One spray (BFB)**	26.72	36.85	34.70	32.76	63.8	68.7	64.7	65.7	56	67	57	60	136	144	142	141
One spray (AFB)***	28.51	32.72	35.52	32.25	62.4	70.7	63.8	65.6	55	69	60	61	138	152	140	143
Two sprays (AH+BFB)	30.12	40.51	40.62	37.08	76.5	83.8	78.7	79.7	68	71	67	69	142	138	140	140
Two sprays (AH+AFB)	31.13	47.63	38.72	39.16	77.8	81.7	79.7	79.7	70	70	69	70	141	140	142	141
Three sprays (AH+BFB+AFB)	40.52	40.72	40.72	44.00	83.7	88.2	84.2	85.4	63	79	73	72	143	140	146	143
Average	29.75	38.30	35.71		70.3	75.3	71.4		61	71	64		140	143	142	
$L.S.D_{0.05}$	B	Zn	B x Zn		B	Zn	B x Zn		B	Zn	B x Zn		B	Zn	B x Zn	
	4.08	6.28	10.99		6.4	9.9	17.2		6	9	16		5	8	13	

*AH = One spray after harvest. **BFB = One spray before full bloom. ***AFB = One spray after full bloom.

Table 3. Effect of Zn and B spray dates on leaf macro-elements content of Anna apple during 2001 and 2002 seasons.

Zn application	N (%)				P (%)				K (%)				Ca (%)			
	B application				B application				B application				B application			
	zero	AH	BFB	Aver.	zero	AH	BFB	Aver.	zero	AH	BFB	Aver.	zero	AH	BFB	Aver.
								2001 season								
Zero	2.59	2.68	2.40	2.56	0.22	0.18	0.20	0.20	1.54	1.64	1.60	1.59	2.02	2.32	2.46	2.27
One spray (AH)*	2.63	2.70	2.36	2.56	0.17	0.15	0.16	0.16	1.60	1.72	1.73	1.68	2.00	2.76	2.58	2.95
One spray (BFB)**	2.83	2.61	2.72	2.72	0.20	0.18	0.15	0.18	1.75	1.76	1.82	1.78	2.06	2.41	2.52	2.33
One spray (AFB)***	2.77	2.80	2.68	2.75	0.19	0.17	0.15	0.17	1.82	1.82	1.73	1.79	1.81	2.56	2.68	2.35
Two sprays (AH+BFB)	2.59	2.68	2.28	2.52	0.16	0.14	0.15	0.15	1.63	1.82	1.81	1.75	2.38	2.78	2.36	2.51
Two sprays (AH+AFB)	2.52	2.77	2.62	2.64	0.17	0.13	0.12	0.14	1.72	1.83	1.82	1.79	1.72	2.60	2.42	2.25
Three sprays (AH+BFB+AFB)	2.67	2.59	2.60	2.62	0.15	0.10	0.12	0.12	1.63	1.72	1.82	1.72	2.02	2.48	2.09	2.23
Average	2.66	2.69	2.52		0.18	0.15	0.15		1.67	1.76	1.76		2.00	2.56	2.44	
L.S.D$_{0.05}$	B	Zn	B x Zn		B	Zn	B x Zn		B	Zn	B x Zn		B	Zn	B x Zn	
	NS	0.42	0.72		0.02	0.03	0.05		0.16	0.25	0.43		0.36	0.55	0.97	
								2002 season								
Zero	2.62	2.76	2.57	2.65	0.20	0.16	0.22	0.19	1.61	1.52	1.48	1.54	2.21	2.70	2.89	2.60
One spray (AH)*	2.49	2.56	2.62	2.56	0.19	0.17	0.16	0.17	1.70	1.77	1.62	1.70	2.36	2.70	2.60	2.55
One spray (BFB)**	2.37	2.46	2.60	2.48	0.22	0.20	0.19	0.20	1.50	1.53	1.77	1.60	2.44	2.81	2.52	2.59
One spray (AFB)***	2.39	2.41	2.46	2.42	0.23	0.19	0.16	0.19	1.58	1.62	1.72	1.64	2.52	2.73	2.62	2.62
Two sprays (AH+BFB)	2.29	2.32	2.36	2.32	0.18	0.15	0.16	0.17	1.69	1.72	1.73	1.71	2.62	2.63	2.58	2.61
Two sprays (AH+AFB)	2.42	2.40	2.30	2.37	0.17	0.13	0.10	0.13	1.72	1.82	1.70	1.75	2.46	2.73	2.60	2.60
Three sprays (AH+BFB+AFB)	2.48	2.36	2.40	2.41	0.14	0.11	0.11	0.12	1.77	1.83	1.60	1.73	2.52	2.70	2.42	2.55
Average	2.44	2.47	2.47		0.19	0.16	0.16		1.65	1.69	1.66		2.45	2.71	2.60	
L.S.D$_{0.05}$	B	Zn	B x Zn		B	Zn	B x Zn		B	Zn	B x Zn		B	Zn	B x Zn	
	NS	0.12	0.22		0.01	0.02	0.03		0.21	0.32	0.57		0.12	0.18	0.32	

*AH = One spray after harvest. **BFB = One spray before full bloom. ***AFB = One spray after full bloom.

Table 4. Effect of Zn and B spray dates on leaf micro-elements content (ppm) of Anna apple during 2001 and 2002 seasons.

Zn application	Mg				Fe				Zn				Mn				B			
	B application				B application				B application				B application				B application			
	zero	AH	BFB	Aver.	zero	AH	BFB	Aver.	zero	AH	BFB	Aver.	zero	AH	BFB	Aver.	zero	AH	BFB	Aver.
2001 season																				
Zero	0.46	0.47	0.60	0.51	163	146	138	149	21	23	25	23	58	62	56	59	20	36	38	31
One spray (AH)*	0.40	0.45	0.46	0.44	150	143	150	148	33	36	33	34	53	52	48	51	22	38	40	33
One spray (BFB)**	0.40	0.40	0.50	0.43	156	150	156	154	28	30	33	30	62	58	63	61	28	42	36	35
One spray (AFB)***	0.50	0.60	0.50	0.53	167	152	148	156	26	35	32	31	60	55	63	59	23	36	40	33
Two sprays (AH+BFB)	0.42	0.56	0.45	0.48	152	140	131	141	38	44	36	39	51	56	42	50	24	32	36	31
Two sprays (AH+AFB)	0.33	0.45	0.52	0.43	151	138	132	140	42	45	40	42	52	40	41	44	28	35	36	33
Three sprays (AH+BFB+AFB)	0.32	0.43	0.57	0.44	146	130	131	136	41	50	45	45	43	38	46	42	25	33	35	31
Average	0.40	0.48	0.51		155	143	141		33	38	35		54	52	51		24	36	37	
$L.S.D_{0.05}$	B	Zn	B x Zn		B	Zn	B x Zn		B	Zn	B x Zn		B	Zn	B x Zn		B	Zn	B x Zn	
	0.05	0.08	0.13		17	26	46		7	11	19		4	6	10		3	5	8	
2002 season																				
Zero	0.48	0.42	0.45	0.45	151	132	140	141	23	20	24	22	62	60	58	60	21	38	32	30
One spray (AH)*	0.40	0.46	0.43	0.43	142	130	136	136	36	38	40	38	48	36	43	42	25	30	33	29
One spray (BFB)**	0.42	0.36	0.40	0.46	140	150	150	147	25	34	31	30	66	58	51	58	23	36	40	33
One spray (AFB)***	0.30	0.56	0.48	0.45	158	150	140	149	27	31	30	29	61	63	66	63	27	30	32	30
Two sprays (AH+BFB)	0.38	0.36	0.40	0.38	140	136	121	132	40	45	37	42	43	52	52	49	30	30	39	33
Two sprays (AH+AFB)	0.30	0.48	0.40	0.39	137	132	130	133	42	40	42	41	40	46	41	42	26	32	30	29
Three sprays (AH+BFB+AFB)	0.30	0.46	0.50	0.42	151	120	126	132	38	40	42	40	43	38	48	43	24	30	30	28
Average	0.37	0.47	0.44		146	136	138		33	35	35		52	50	51		25	32	34	
$L.S.D_{0.05}$	B	Zn	B x Zn		B	Zn	B x Zn		B	Zn	B x Zn		B	Zn	B x Zn		B	Zn	B x Zn	
	0.08	0.12	0.22		12	18	32		4	6	11		8	12	22		5	7	12	

*AH = One spray after harvest. **BFB = One spray before full bloom. ***AFB = One spray after full bloom.

Table 5. Effect of Zn and B spray dates on TSS, acidity and anthocyanin contents of Anna apple during 2001 and 2002 seasons.

Zn application	TSS (%)				Acidity (%)				Anthocyanin (mg/100 g fresh weight)			
	B application				B application				B application			
	zero	AH	BFB	Aver.	zero	AH	BFB	Aver.	zero	AH	BFB	Aver.
						2001 season						
Zero	11.50	12.98	12.26	12.25	1.12	0.80	0.76	0.89	11.40	12.36	12.40	12.05
One spray (AH)*	12.76	12.80	12.90	12.82	1.01	0.86	0.92	0.93	12.85	14.80	14.76	14.14
One spray (BFB)**	11.86	12.36	12.40	12.21	1.09	0.92	0.86	0.96	11.70	12.66	12.86	12.41
One spray (AFB)***	12.00	12.80	12.86	12.55	1.10	0.83	0.86	0.93	11.86	12.52	12.26	12.21
Two sprays (AH+BFB)	12.60	12.90	12.82	12.77	0.96	0.76	0.80	0.84	13.25	14.60	14.42	14.09
Two sprays (AH+AFB)	12.72	12.80	12.90	12.81	0.98	0.70	0.82	0.83	13.86	14.80	14.60	14.42
Three sprays (AH+BFB+AFB)	12.80	13.20	13.30	13.10	0.90	0.62	0.70	0.74	14.26	14.80	15.06	14.71
Average	12.32	12.83	12.78		1.02	0.78	0.82		12.74	13.79	13.77	
$L.S.D_{0.05}$	B	Zn	B x Zn		B	Zn	B x Zn		B	Zn	B x Zn	
	0.32	0.50	0.86		0.17	0.26	0.46		0.76	1.17	2.05	
						2002 season						
Zero	12.08	12.50	12.60	12.39	1.18	0.92	0.90	1.00	9.72	10.62	10.52	10.29
One spray (AH)*	12.24	13.86	13.60	13.23	1.00	0.80	0.78	0.86	10.88	11.26	11.42	11.19
One spray (BFB)**	11.86	12.42	12.66	12.31	1.10	1.00	0.88	0.99	10.06	10.36	10.50	10.31
One spray (AFB)***	11.67	12.50	12.40	12.19	1.12	0.90	0.92	0.98	10.18	10.40	10.60	10.39
Two sprays (AH+BFB)	12.42	13.60	13.46	13.16	0.90	0.86	0.80	0.87	11.26	11.90	12.30	11.82
Two sprays (AH+AFB)	12.26	13.66	13.36	13.09	0.90	0.80	0.78	0.83	11.73	12.26	11.86	11.95
Three sprays (AH+BFB+AFB)	12.48	13.26	13.42	13.05	0.93	0.70	0.64	0.76	12.26	12.86	13.07	12.73
Average	12.14	13.11	13.07		1.02	0.85	0.81		10.87	11.38	11.47	
$L.S.D_{0.05}$	B	Zn	B x Zn		B	Zn	B x Zn		B	Zn	B x Zn	
	0.43	0.66	1.16		0.11	0.17	0.30		0.46	0.71	1.24	

*AH = One spray after harvest. **BFB = One spray before full bloom. ***AFB = One spray after full bloom.

Table 6. Effect of Zn and B spray dates on fruit reducing sugars, non-reducing sugars, starch and total sugars (% on fresh weight basis) of Anna apple during 2001 and 2002 seasons.

Zn application	Reducing sugars				Non-educing sugars				Starch				Total sugars			
	B application				B application				B application				B application			
	zero	AH	BFB	Aver.	zero	AH	BFB	Aver.	zero	AH	BFB	Aver.	zero	AH	BFB	Aver.
								2001 season								
Zero	7.31	8.20	8.00	7.84	2.17	2.42	2.23	2.27	2.18	2.42	2.36	2.32	9.48	10.62	10.23	10.11
One spray (AH)*	7.92	8.52	8.71	8.38	2.32	2.62	2.53	2.49	2.32	2.70	2.80	2.61	10.24	11.14	11.24	10.87
One spray (BFB)**	7.90	7.98	7.99	7.96	2.10	2.20	2.25	2.18	2.26	2.56	2.42	2.41	10.00	10.18	10.24	10.14
One spray (AFB)***	7.78	8.21	8.10	8.03	2.08	2.41	2.32	2.27	2.20	2.32	2.41	2.31	9.86	10.62	10.42	10.30
Two sprays (AH+BFB)	8.20	8.42	8.40	8.34	3.04	3.20	3.16	3.13	2.56	2.86	3.18	2.87	11.24	11.62	11.56	11.47
Two sprays (AH+AFB)	8.00	8.40	8.42	8.27	3.14	3.30	3.44	3.29	2.82	3.01	2.92	2.92	11.14	11.70	11.86	11.57
Three sprays (AH+BFB+AFB)	8.21	8.52	8.46	8.23	3.25	3.54	3.66	3.48	3.01	3.26	3.16	3.14	11.46	12.06	12.12	11.88
Average	7.90	8.32	8.30		2.59	2.81	2.80		2.48	2.73	2.75		10.49	11.13	11.10	
$L.S.D_{0.05}$	B	Zn	B x Zn		B	Zn	B x Zn		B	Zn	B x Zn		B	Zn	B x Zn	
	0.25	0.39	0.68		0.46	0.71	1.24		2.48	0.30	0.54		0.28	0.43	0.75	
								2002 season								
Zero	7.40	7.82	7.67	7.63	3.32	2.70	2.63	2.55	2.32	2.63	2.76	2.57	9.72	10.52	10.30	10.18
One spray (AH)*	7.67	8.26	8.34	8.08	2.53	2.94	2.92	2.80	2.60	2.90	3.06	2.85	10.18	11.20	11.26	10.88
One spray (BFB)**	7.72	8.06	8.12	7.97	2.34	2.92	3.06	2.77	2.28	2.70	2.70	2.56	10.06	11.00	11.18	10.75
One spray (AFB)***	7.38	8.02	7.73	7.71	2.49	2.80	2.67	2.65	2.15	2.62	2.58	2.45	9.87	10.82	10.40	10.36
Two sprays (AH+BFB)	8.30	8.68	8.60	8.53	3.06	3.18	3.20	3.15	3.06	3.36	3.40	3.27	11.36	11.86	11.80	11.67
Two sprays (AH+AFB)	8.26	8.73	8.70	8.56	2.92	3.15	3.20	3.09	3.18	3.40	3.52	3.37	11.18	11.88	11.90	11.65
Three sprays (AH+BFB+AFB)	8.36	8.50	8.41	8.42	3.04	3.40	3.69	3.38	3.26	3.62	3.46	3.45	11.40	11.90	12.10	11.80
Average	7.87	8.30	8.22		2.67	3.01	3.05		2.69	3.03	3.07		10.54	11.31	11.28	
$L.S.D_{0.05}$	B	Zn	B x Zn		B	Zn	B x Zn		B	Zn	B x Zn		B	Zn	B x Zn	
	0.29	0.44	0.78		0.27	0.42	0.73		0.13	0.20	0.35		0.45	0.69	1.21	

*AH = One spray after harvest. **BFB = One spray before full bloom. ***AFB = One spray after full bloom.

Table 7. Effect of Zn and B spray dates on fruit firmness and breakdown at harvest and after 40 days storage at 0°C of Anna apple during 2001 and 2002 seasons.

Zn application	Fruit firmness (lb/in²)								Fruit breakdown (%)							
	At harvest				After cold storage				At harvest				After cold storage			
	B application				B application				B application				B application			
	zero	AH	BFB	Aver.	zero	AH	BFB	Aver.	zero	AH	BFB	Aver.	zero	AH	BFB	Aver.
								2001 season								
Zero	8.60	9.80	10.02	9.47	4.12	5.32	5.21	4.88	10.12	8.06	7.80	8.66	20.70	15.76	14.86	17.11
One spray (AH)*	9.26	10.86	10.62	10.25	4.86	5.86	6.21	5.64	8.12	7.06	7.13	7.44	16.36	14.36	15.06	15.26
One spray (BFB)**	9.12	10.18	10.26	9.85	4.21	5.76	5.86	5.28	9.60	8.00	7.80	8.47	17.81	15.06	15.12	16.00
One spray (AFB)***	9.26	10.08	10.13	9.82	4.36	5.61	5.86	5.28	9.86	8.12	8.21	8.73	16.06	14.08	15.08	15.07
Two sprays (AH+BFB)	9.86	10.90	11.12	10.63	5.86	6.13	5.96	5.98	7.62	6.56	6.46	6.88	15.62	13.36	14.06	14.35
Two sprays (AH+AFB)	10.06	11.23	11.40	10.90	5.72	6.08	6.18	5.99	7.60	6.21	6.01	6.61	14.82	12.63	12.51	13.32
Three sprays (AH+BFB+AFB)	10.26	11.50	11.30	11.02	5.30	6.18	6.00	5.83	7.42	6.06	6.21	6.56	14.31	11.82	12.70	12.94
Average	9.49	10.65	10.69		4.92	5.85	5.90		8.62	7.15	7.09		16.53	13.87	14.20	
$L.S.D_{0.05}$	B	Zn	B x Zn		B	Zn	B x Zn		B	Zn	B x Zn		B	Zn	B x Zn	
	0.71	1.09	1.91		0.36	0.55	0.97		0.31	0.48	0.84		1.20	1.85	3.23	
								2002 season								
Zero	9.26	10.08	10.18	9.84	4.26	5.42	5.56	5.08	9.18	7.61	7.56	8.12	21.36	15.06	15.26	17.23
One spray (AH)*	9.80	10.46	10.60	10.29	4.60	5.80	5.90	5.43	7.21	6.36	6.42	6.66	15.12	14.52	14.31	14.65
One spray (BFB)**	9.42	10.68	10.70	10.27	4.06	5.32	5.42	4.93	8.36	7.80	7.60	7.92	17.62	15.12	15.06	15.93
One spray (AFB)***	9.30	10.77	10.82	10.30	6.26	5.56	5.70	5.17	8.06	7.76	7.42	7.75	18.70	15.00	14.86	16.19
Two sprays (AH+BFB)	10.23	10.96	11.06	10.75	4.86	6.23	6.18	5.76	6.26	5.76	5.46	5.83	14.82	13.82	13.60	14.08
Two sprays (AH+AFB)	10.56	11.08	11.26	10.97	4.86	6.42	6.26	5.85	6.18	5.31	5.76	5.75	14.60	13.72	13.76	14.03
Three sprays (AH+BFB+AFB)	10.68	11.42	11.28	11.17	5.21	6.56	6.32	6.03	6.06	5.06	5.13	5.42	14.07	13.13	12.86	13.35
Average	9.89	10.78	10.84		4.59	5.90	5.91		7.33	6.52	6.48		16.61	14.34	14.24	
$L.S.D_{0.05}$	B	Zn	B x Zn		B	Zn	B x Zn		B	Zn	B x Zn		B	Zn	B x Zn	
	0.43	0.66	1.16		0.22	0.34	0.59		0.24	6.52	0.65		1.06	1.63	2.9	

*AH = One spray after harvest. **BFB = One spray before full bloom. ***AFB = One spray after full bloom.

الملخص العربى

أستجابة أشجار التفاح صنف أنا الى عدد و وقت الرشات الورقية بالزنك و البورون

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تـم إجراء هذه الدراسة على أشجار التفاح صنف أنا خلال موسمى النمو ٢٠٠٠-٢٠٠١ و ٢٠٠١-٢٠٠٢. فقـد تـم رش الأشجار بكل من البوركس بتركيز ٢٠٠ جزء فى المليون (مرة واحدة) وكبريتات الزنك بـتركيز ٠,٣% (مرة ومرتين وثلاث مرات) كل على حده وكذلك التوليفات الممكنة معاً فى مواعيد رش مختلفة كالآتى: بعد جمع المحصول فى نهاية سبتمبر ٢٠٠٠ و ٢٠٠١ قبل الإزهار الكامل وبعد الإزهار الكامل من كل موسـم. وقد وجد أن الإضافة الورقية للبورون فقط بعد الجمع أو قبل الإزهار الكامل وإضافة الزنك فقط مرتين أو ثلاث مرات أدي إلى زيادة معنوية فى نسبة العقد والمحصول وصفات الجودة والقدرة التخزينية للثمار. ولكن لـم يـتأثر محتوى الأوراق من النيتروجين والبوتاسيوم والحديد بأى من الرش بالزنك والبورون. وبصفة عامة وجـد أن رشـة واحدة من البورون مع رشتين أو ثلاث رشات من الزنك أدى إلى زيادة فى نمو الأشجار وعقد الـثمار ونسـبة الـثمار المتبقية على الأشجار وبالتالى المحصول. كما تحسنت صفات الجودة عند الجمع وبعد التخزين.