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Effect of Zinc and Boron on Vegetative Growth and yield of Early Sweet grape under desert Conditions

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ABSTRACT

Experiment was carried out throughout two successive seasons of 2017 and 2018 on Early Sweet vines grown in sandy soil under drip irrigation system in a private vineyard located at Giza governorate, Egypt to investigate the role of the zinc and boron elements as well as spraying time in improving vegetative growth and yield of Early Sweet table grape (*Vitis vinifera* L.). Moreover, all studied treatments significantly improved leaf area; leaf chlorophyll contents; shoot length; number of leaves per shoot; Weight of pruning wood; clusters number per vine and total yield per vine. The best results were obtained on the vines that sprayed with 500 ppm Zn with 250 ppm B at full bloom. It could be concluded that spraying Zn at 500ppm, B at 250ppm annually was necessary to get high yield of Early Sweet grapevines.

Keywords: zinc, boron, Early Sweet grapevines, vegetative growth, yield.

Introduction

Grape is considered as one of the foremost well is known and favorite fruits within the world, because of an amazing flavor, decent taste and high nutritional value. In the last few years, the cultivated area of grapes in Egypt has grown rapidly in the last two decades reached about 200,000 feddans producing about 1.800.000 tons according to the statistics of the Ministry of Agriculture (Ministry of Agriculture and Land Reclamation, 2020). So that grapevine is considered one of the most important fruit crops ranked the second major fruit crops after citrus.

Early sweet grapevine cultivar grown successfully in Egypt and it is recognized as an early cultivar in the Egyptian market. Moreover, it is an early ripening cultivar (in the last week of May). It has a great importance for the local or international markets. It has a greater chance of being exported with minimum competition but there are major problems associated with this cultivar, such as poor vegetative growth (Abdel Rehim *et al.,* 2022; Or *et al.,* 2020 and Belal *et al.,* 2023). Grape production and quality depend on a variety of factors, which includes climate, irrigation, vine yard maintenance, mineral nutrition etc. High temperature is a major environmental factor limiting grape yield and affecting berry quality (Liu *et al.,* 2014). Heat is a stress factor that will become more prevalent due to increasing climate change and is known to negatively affect crop yield and quality, posing a severe threat to food security for future generations. Warm temperatures encourage development of the canopy vines, but temperatures over 35°C, heat stress will impact on the physiology of the vine (Rogiers *et al.,* 2022). Zinc application alleviated the heat stress by enhancing shoot zinc concentration, superoxide dismutase activity and chlorophyll content and that protect plant growth from heat stress (Han *et al.,* 2020 and Hendrix *et al.,* 2022). Grapevine is an important dry land pulse crop in many parts of the world. It is worth mentioning in a number of drought regions, drought is accompanied with zinc deficiency, one of the most serious problems causing significant decreases in yield and quality in viticulture and it recommend Zn spraying as an environmentally friendly and sustainable cultural (Sabir and Sari 2019).

On other hand, integrated nutrient management plays a vital role in increasing the yield of crop. Particularly the role of secondary and micronutrients are very important for vine growth and productivity (Swathi *et al.,* 2019). Fertilization is an important and limiting factor for growth and

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productivity of grapevines (Soliman *et al.,* 2022). Zinc and boron are most important micronutrient in fruit set and development in vineyards and foliar applications of B and Zn to maintain adequate micronutrient concentrations are a common vineyard management practice (Christensen *et al.,* 2006). Both Zn and B have significant effect in improving vegetative development; pollination; fruit set and total yield of grapevine cultivars (Motesharezade *et al.,* 2001; Ahmad *et al.,* 2014; Song *et al.,* 2015; Hegazy *et al.,* 2018 and Tadayon and Moafpourian, 2019). But zinc and boron are soluble in water, so it is easily lost with irrigation water, it is absorbed and replaced in the colloidal part thus it decreases in lands with low organic matter content, also these deficiency are common in high-pH soils (Storey *et al.,* 1971; Graham *et al.,* 1992; White & Zasoski, 1999 and Tavallali & Rahemi, 2007). So, zinc and boron deficiency are common in grape cultivations expanded areas because it is sandy land with poor organic matter content. Also, deficiencies of B and Zn are particularly critical because of their low mobility in most species and their essential roles in vegetative and reproductive growth (Marschner, 2012; Song *et al.,* 2015).

The purposes of this research were to study the effect of foliar zinc and boron and application dates alone and/or their combinations on vegetative growth and yield per vine of "Early Sweet" grapevines.

2. Material and Methods

This study was carried out during two successive seasons of 2017 and 2018 in a private grapevine orchard, located on Cairo-Alexandria desert road about 60 km from Cairo, Egypt.

"Early Sweet" grapevine of ten years old grown in sandy loam soil, and spaced 1.5x3m apart under drip irrigation system from a well were devoted for this study. Chemical analyses of the experimental soil shown in (Table 1). Moreover, the chemical analysis of the used water for irrigation (Table 2).

Table 1: Analysis of experimental soil in 2017 and 2018 seasons.

Soil Depth cm	pH Soil past	E.Ce (dSm^{-1})	Soluble cations (meq/l)				Soluble anions (meq/l)			
			Ca^{++}	K^{+}	Na^{+}	Mg^{++}	Cl^{-}	$SO_4^{=}$	HCO_3^{-}	$CO_3^{=}$
0-30	7.77	2.55	3.0	1.33	20.13	1.1	21.8	3.06	0.7	-
30-60	7.48	2.63	3.7	1.01	20.41	1.2	22	3.42	0.9	-

Table 2: Chemical analysis of water used for irrigation in 2017 and 2018 seasons.

pH	E.C (dSm^{-1})	Soluble cations (meq/l)				Soluble anions (meq/l)			
		Ca^{++}	K^{+}	Na^{+}	Mg^{++}	Cl^{-}	$SO_4^{=}$	HCO_3^{-}	$CO_3^{=}$
8.4	1.19	1.5	0.89	8.45	1.12	6.46	4.1	1.4	-

The vines were trained to spur pruning under "Baron" system and pruned on 25th December with 56 buds per vine for all the selected vines on the basis of 12 fruiting spurs x 4 buds plus 4 replacements spurs x 2 buds/vine, beside sprayed Dromx in the first week of January from each season. The chosen vines were nearly similar in growth and subjected to the normal horticultural managements

This study is considered a Factorial experiment, as it involved three factors as follows:

A. **Dates of application:** three dates of application i.e. Full bloom or one week after full bloom or two weeks after full bloom
B. **Foliar spray of zinc rates:** three rates of zinc sulphate ($Zn_2SO_4.H_2O$ 36%) (0, 250, 500 ppm).
C. **Foliar spray of boron rates:** three rates of boric acid (H_2BO_3) (0, 250, 500 ppm).

This study is considered a factorial experiment, hence a split-split plot is devoted to the dates of application as main plot, whereas foliar spray of zinc rates occupied sub plot. And foliar spray of boron rates located in the sub-sub plots. The selected vines were sprayed once until runoff. Triton B at 0.1% as a wetting agent was used with all treatments to spray solution including the control "tap water ". The treatment of each factor was replicated three times and each replicate was represented by one plant.

Response of "Early Sweet" grapevines to the tested dates applications, zinc sulphate and boric acid treatments as well as their interactions were evaluated through the following parameters.

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1.1. Vegetative characteristics

Leaf of the apical 5th and 6th leaves was chosen to measure leaf area and chlorophyll content. Leaf area (cm^2) was estimated by using Portable area mod Li 3100 Ali (Li-cor). Whereas, the total chlorophyll content in the leaves was measured using a Minolta chlorophyll meter SPAD- 502, and converted reading to (mg/m^2) according to the equation: Chl= -80.05+ 10.40 [SPAD – 502] according to Monje and Bugbee, (1992). At the end of growth stage of each season, shoot length (m) was measured and number of leaves per current season shoot was counted once at the first week of September. Weight of one year old pruning wood (kg) was recorded at the pruning time in the last week in December.

1.2. Yield (kg/vine)

At the last week of May, clusters number per vine and cluster weight mean were carried out to determine estimate total yield per vine.

Yield (kg)/kg pruning

Using the following equation according to Cawthon and Morris, (1977).

$$\text{Yield (kg)/kg pruning} = \frac{\text{Total yield per vine (kg)}}{\text{Pruning wood per vine (kg)}}$$

1.3. Statistical Analysis

The obtained data in 2017 and 2018 seasons were subjected to analysis of variance according to Clarke and Kempson (1997). Means were differentiated using Range test at the 0.05 level (Duncan, 1955).

3. Results and Discussion

3.1. Vegetative characteristics

3.1.1. Leaf area (cm^2)

It is clear from Fig (1) that three application dates had insignificant effect on leaf area in both seasons. Moreover, 500 ppm zinc foliar spray produced significant effect in both seasons and more expanded leaves than other zinc rates**.** Furthermore, 250 and 500 ppm boron foliar spray vines produced similar effect and high expanded leaves as compared with those untreated vines.

On the other hand data in table (3) show that, the interaction between application dates and foliar spray with zinc reveals that 500 ppm zinc foliar spray at full bloom exerted the highest positive effect on leaf area in both seasons. In addition, the interaction between application dates and foliar spray with boron reveals that in both seasons, the combination of 250 ppm and/or ppm B foliar spray at full bloom, 250 ppm and/or ppm B foliar spray at one week after full bloom, 250 ppm or 500 ppm B foliar spray at two week after full bloom and 500 ppm B foliar spray at one week after full bloom induced statistically similar and high positive effect on leaf area as compared with other combinations in this respect. Furthermore, foliar spray with Zn at 500 ppm associated with B at 250 ppm exerted the highest significant effect on leaf area as compared with other combinations in both seasons.

Finally, the interaction among the three studied factors indicates that the combination of 500 ppm Zn + 250 ppm B foliar spray at full bloom surpassed the other combinations in enhancing leaf area as compared with other combinations in both seasons.

3.1.2. Leaf total chlorophyll content (mg/m^2)

Fig. (2) illustrates that application date (full bloom) had the highest values of chlorophyll in first season, but in the second season, three application dates failed to induce and positive effect on leaf chlorophyll. Moreover, vines foliar spray with zinc at 500 ppm exerted high positive effect on leaf chlorophyll content than other treatments. Furthermore, 250 ppm B foliar spray in both seasons and 500 ppm B foliar spray in the first season gave similar effect and the highest values of total chlorophyll content in this respect.

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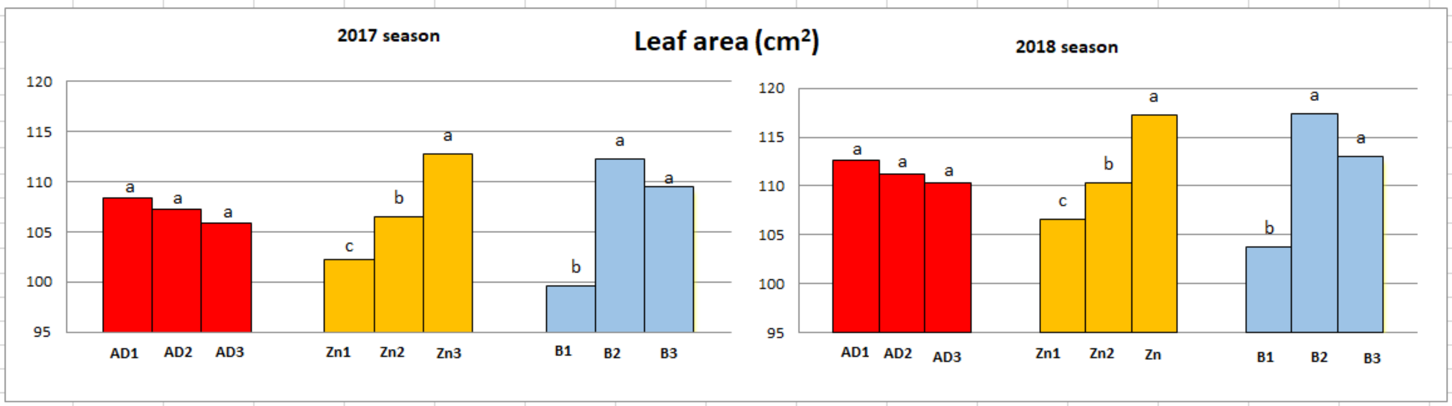

Fig. 1: Effect of application dates (AD), foliar spray of Zn and B on leaf area (cm^2) of "Early Sweet" grapes during 2017 and 2018 seasons.

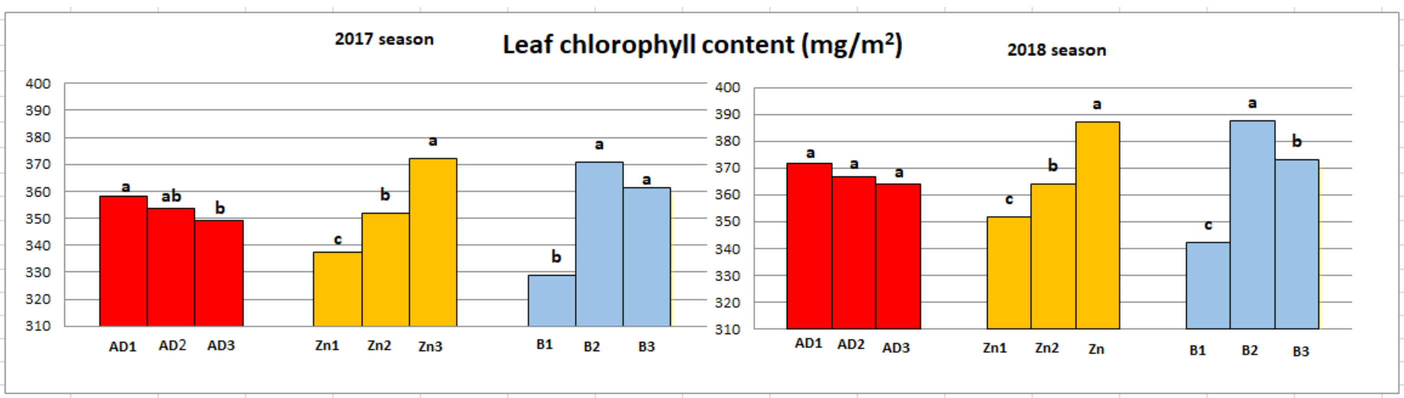

Fig. 2: Effect of application dates (AD), foliar spray of Zn and B on leaf chlorophyll content (mg/m^2) of "Early Sweet" grapes during 2017 and 2018 seasons.

AD1 = Full bloom **AD2** = One week after full bloom **AD 3** = Two weeks after full bloom
Zn1 = 0 ppm Zn **Zn2** = 250 ppm Zn **Zn 3** = 500 ppm Zn
B1 = 0 ppm B **B2** = 250 ppm B **B 3** = 500 ppm B

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Table 3: Effect of interactions among application dates, foliar spray of Zn and B on leaf area (cm^2) and leaf chlorophyll content (mg/m^2) of "Early Sweet" grapes during 2017 and 2018 seasons.

Treatments	Leaf area (cm^2) 2017	Leaf area (cm^2) 2018	Leaf chlorophyll (mg/m^2) 2017	Leaf chlorophyll (mg/m^2) 2018
Effect of interaction between application dates and zinc				
Full bloom + 0 ppm Zn	103.6 d	107.2 d	342.1 d	353.9 d
Full bloom +250 ppm Zn	107.3 b-d	110.8 b-d	354.2 b-d	365.7 b-d
Full bloom + 500 ppm Zn	114.4 a	119.9 a	377.4 a	395.7 a
One week after full bloom + 0 ppm Zn	102.1 d	107.0 d	336.9 d	353.1 d
One week after full bloom +250 ppm Zn	107.1 b-d	110.3 cd	353.4 b-d	363.6 cd
One week after full bloom +500 ppm Zn	112.3 ab	116.3 ab	370.7 ab	383.9 ab
Two weeks after full bloom + 0 ppm Zn	101.0 d	105.6 d	333.2 d	348.6 d
Two weeks after full bloom + 250 ppm Zn	105.2 cd	109.9 cd	347.2 cd	362.9 cd
Two weeks after full bloom+ 500 ppm Zn	111.4 a-c	115.4 a-c	367.4 a-c	381.0 a-c
Effect of interaction between application dates and Boron				
Full bloom + 0ppm B	101.1 b-d	104.1 bc	333.6 b	343.6 c
Full bloom +250ppm B	113.7 a	119.5 a	375.4 a	394.6 a
Full bloom + 500 ppm B	110.5 a	114.3 a	364.8 a	377.1 ab
One week after full bloom+ 0ppm B	99.8 cd	103.9 bc	329.4 b	342.8 c
One week after full bloom+250ppm B	112.2 a	116.7 a	370.0 a	385.2 ab
One week after full bloom+500ppm B	109.6 ab	112.9 a	361.6 a	372.6 b
Two weeks after full bloom+ 0ppm B	98.0 d	103.1 c	323.4 b	340.4 c
Two weeks after full bloom+ 250ppm B	111.0 a	116.0 a	366.3 a	383.0 ab
Two weeks after full bloom+ 500ppm B	108.5 a-c	111.8 ab	358.1 a	369.0 b
Effect of interaction between zinc and Boron				
0 ppm Zn + 0 ppm B	95.2 e	101.4 f	314.1 e	334.6 g
0 ppm Zn +25 0 ppm B	106.5 b-d	111.1 b-e	351.7 cd	366.8 c-e
0 ppm Zn + 500 ppm B	105.0 cd	107.3 c-f	346.4 cd	354.2 d-f
250 ppm Zn + 0 ppm B	100.2 de	103.6 ef	330.8 de	341.6 fg
250 ppm Zn + 250 ppm B	110.9 a-c	114.3 bc	365.9 bc	377.3 bc
250 ppm Zn + 5000 ppm B	108.5 b-d	113.1 b-d	358.2 bc	373.2 b-d
500 ppm Zn + 0 ppm B	103.5 c-e	106.2 d-f	341.6 cd	350.7e-g
500 ppm Zn + 250 ppm B	119.5 a	126.8 a	394.2 a	418.7 a
500 ppm Zn + 500 ppm B	115.1 ab	118.6 b	379.8 ab	391.2 b

Effect of application dates, zinc and Boron

Application dates	Zn (PPM)	B (PPM)	Leaf area (cm^2) 2017	Leaf area (cm^2) 2018	Leaf chlorophyll 2017	Leaf chlorophyll 2018
Full bloom	0	0	98.1 f-h	102.0 fg	323.7 g-i	336.3 gh
Full bloom	0	250	107.4 a-h	112.2 b-g	354.3 b-h	370.7 c-f
Full bloom	0	500	105.4 b-h	107.5 d-g	348.3 c-i	354.7 e-h
Full bloom	250	0	101.0 d-h	103.7 e-g	333.7 f-i	342.0 f-h
Full bloom	250	250	111.6 a-f	115.2 b-f	368.7 a-f	380.0 b-e
Full bloom	250	500	109.2 a-g	113.7 b-g	360.3 b-g	375.0 c-f
Full bloom	500	0	104.0 b-h	106.8 d-g	343.3 d-i	352.3 e-h
Full bloom	500	250	122.2 a	131.1 a	403.3 a	433.0 a
Full bloom	500	500	116.9 a-c	121.7 a-c	385.7 a-d	401.7 a-c
One week after full bloom	0	0	94.6 gh	101.8 fg	312.0 hi	336.0 gh
One week after full bloom	0	250	106.2 b-h	111.7 b-g	350.7 b-h	368.7 c-g
One week after full bloom	0	500	105.5 b-h	107.5 d-g	348.0 c-i	354.7 e-h
One week after full bloom	250	0	101.1 d-h	103.7 e-g	333.7 f-i	341.3 f-h
One week after full bloom	250	250	111.6 a-f	114.0 b-g	368.0 a-f	376.0 c-e
One week after full bloom	250	500	108.7 a-g	113.1 b-g	358.7 b-g	373.3 c-f
One week after full bloom	500	0	103.9 b-h	106.3 d-g	342.7 e-i	351.0 e-h
One week after full bloom	500	250	118.6 ab	124.5 ab	391.3 ab	411.0 ab
One week after full bloom	500	500	114.6 a-d	118.1 a-d	378.0 a-e	389.7 b-d
Two weeks after full bloom	0	0	92.9 h	100.4 g	306.7 i	331.3 h
Two weeks after full bloom	0	250	106.0 b-h	109.3 c-g	350.0 b-h	361.0 d-h
Two weeks after full bloom	0	500	104.0 b-h	107.0 d-g	343.0 e-i	353.3 e-h
Two weeks after full bloom	250	0	98.5 e-h	103.4 e-g	325.0 g-i	341.3 f-h
Two weeks after full bloom	250	250	109.4 a-g	113.9 b-g	361.0 a-g	376.0 c-e
Two weeks after full bloom	250	500	107.7 a-h	112.5 b-g	355.7 b-g	371.3 c-f
Two weeks after full bloom	500	0	102.7 c-h	105.6 d-g	338.7 e-i	348.7 e-h
Two weeks after full bloom	500	250	117.6 a-c	124.9 ab	388.0 a-c	412.0 ab
Two weeks after full bloom	500	500	113.8 a-e	115.9 b-e	375.7 a-f	382.3 b-e

Means within each column for each interaction followed by the same letter (s) are not significantly at 5% level.

The presented data in table (3) show the interaction between application dates and foliar spray with zinc reveals that 500 ppm zinc foliar spray at full bloom gave the highest significant effect on leaf chlorophyll content in both seasons. In addition, the interaction between application dates and foliar spray with boron reveals that, the combination of 250 ppm or 500 ppm B foliar spray at full bloom or one week after full bloom or two week after full bloom in first season, 250 ppm B foliar spray at full bloom, in the second season, induced statistically similar and high significant effect on leaf chlorophyll content as compared with other combinations in this respect. Combination of foliar spray with Zn at 500 ppm plus B at 250 ppm exerted the highest positive effect on leaf chlorophyll content as compared with other combinations in both seasons.

Finally, the interaction among the three studied factors indicates that the combination of 500 ppm Zn plus 250 ppm B foliar spray at full bloom surpassed the other combinations in enhancing leaf chlorophyll content as compared with other combinations in both seasons.

3.1.3. Shoot length (m)

It is clear from Fig. (3) that three application dates had no significant effect on Shoot length in both seasons. Moreover, 500 ppm zinc foliar spray vines resulted in increasing Shoot length as compared with other treatments in both seasons. Boron foliar spray at 250 and 500 ppm produced similar effect and the highest Shoot length as compared with those untreated vines.

It is obvious from table (4) that the interaction between application dates and foliar spray with zinc reveals that 500 ppm zinc foliar spray at full bloom gave the highest Shoot length in both seasons. In addition, the interaction between application dates and foliar spray with boron reveals that the combination of 250 or 500 ppm B foliar spray at full bloom and combination of 250 ppm B foliar spray at one week after full bloom in the first seasons, and the combination of 250 or 500 ppm B foliar spray at one week after full bloom and combination of 250 ppm B foliar spray at two week after full bloom in the second seasons, increased Shoot length as compared with control. Combination of foliar spray with Zn at 500 ppm plus B at 250 ppm improved Shoot length as compared with other combinations in both seasons.

Finally, the interaction among the three studied factors indicates that the combinations of 500 ppm Zn plus 250 ppm B foliar spray at full bloom surpassed the other combinations in increasing Shoot length as compared with other combinations in both seasons.

3.1.4. No. of leaves per shoot

It is clear from Fig. (4) that three application dates failed to induce any significant effect on number of leaves per shoot in both seasons. Moreover, 500 ppm zinc foliar spray vines resulted in increasing number of leaves per shoot as compared with other treatments in both seasons. Furthermore, 250 ppm or 500 ppm B foliar spray in first season and 250 ppm B foliar spray in the second gave similar effect and recorded the highest values of number of leaves per shoot in this respect.

Data of table (4) reveal that the interaction between application dates and foliar spray with zinc reveals that 500 ppm zinc foliar spray at full bloom or one week after full bloom gave similar and high positive effect on number of leaves per shoot in both seasons. In addition, the interaction between application dates and foliar spray with boron reveals that the combination of 250 ppm or 500 ppm B foliar spray at full bloom or at one week after full bloom or at two weeks after full bloom in the first seasons, 250 ppm or 500 ppm B foliar spray at full bloom and 250 ppm B foliar spray at one week after full bloom or at two weeks after full bloom in the second seasons induced similar and high positive effect on number of leaves per shoot as compared with other combinations. Combination of 500 ppm Zn plus 250 ppm B foliar spray gave the highest positive effect on number of leaves per shoot as compared with other combinations in both seasons.

Finally, the interaction among the three studied factors indicates that the interactions of 500 ppm Zn plus 250 ppm B foliar spray at full bloom surpassed the other combinations in improving number of leaves per shoot as compared with other combinations in both seasons.

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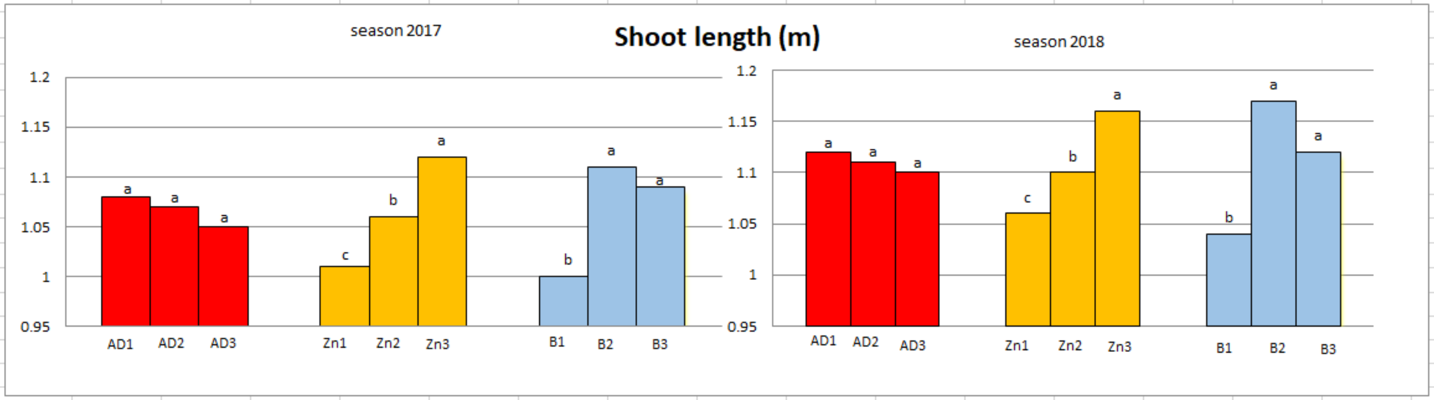

Fig. 3: Effect of application dates (AD), foliar spray of Zn and B on Shoot length (m) per vine of "Early Sweet" grapes during 2017 and 2018 seasons.

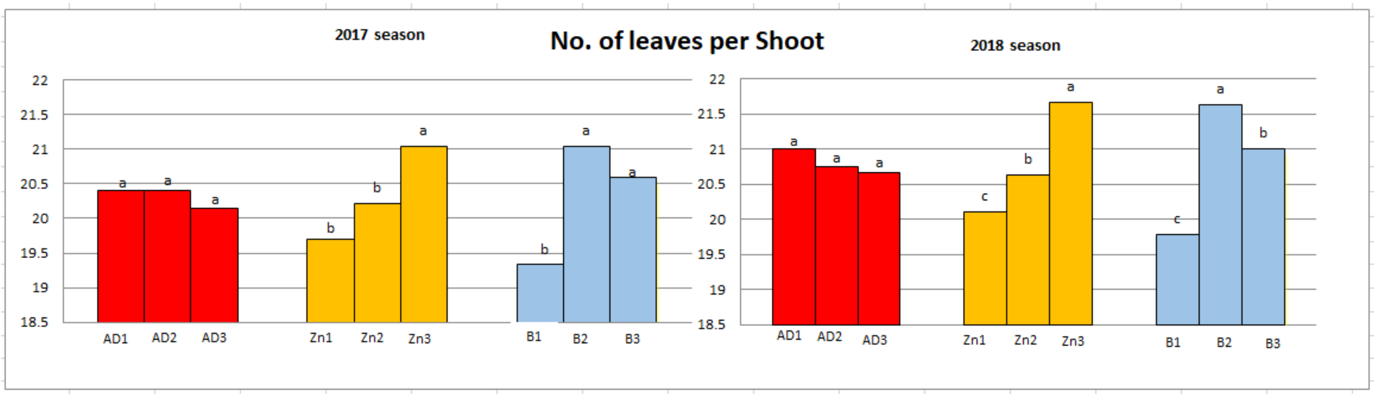

Fig. 4: Effect of application dates (AD), foliar spray of Zn and B on number of leaves per Shoot of "Early Sweet" grapes during 2017 and 2018 seasons.

AD1 = Full bloom | **AD2** = One week after full bloom | **AD 3** = Two weeks after full bloom
Zn1 = 0 ppm Zn | **Zn2** = 250 ppm Zn | **Zn 3** = 500 ppm Zn
B1 = 0 ppm B | **B2** = 250 ppm B | **B 3** = 500 ppm B

Table 4: Effect of interactions among application dates, foliar spray of Zn and B on shoot length (m) and No. of leaves per shoot of "Early Sweet" grapes during 2017 and 2018 seasons.

Treatments	Shoot length (m)		No. of leaves per shoot	
	2017	2018	2017	2018
Effect of interaction between application dates and zinc				
Full bloom + 0ppm Zn	1.02 cd	1.07 d	19.89 c	20.22 cd
Full bloom +250ppm Zn	1.07 a-c	1.10 b-d	20.22 a-c	20.78 bc
Full bloom + 500 ppm Zn	1.14 a	1.19 a	21.11 a	22.00 a
One week after full bloom+ 0ppm Zn	1.01 cd	1.07 d	19.78 c	20.11 cd
One week after full bloom+250ppm Zn	1.07 a-c	1.10 b-d	20.33 a-c	20.44 cd
One week after full bloom+500ppm Zn	1.12 ab	1.15 ab	21.11 a	21.67 a
Two weeks after full bloom+ 0ppm Zn	1.00 d	1.05 d	19.44 c	20.00 d
Two weeks after full bloom+ 250ppm Zn	1.05 b-d	1.09 cd	20.11 bc	20.67 b-d
Two weeks after full bloom+ 500ppm Zn	1.11 ab	1.15 ab	20.89 ab	21.33 ab
Effect of interaction between application dates and Boron				
Full bloom + 0ppm B	1.01 b-d	1.04 bc	19.44 b	19.78 c
Full bloom +250ppm B	1.12 a	1.19 a	21.22 a	22.00 a
Full bloom + 500 ppm B	1.10 a	1.14 a	20.56 a	21.22 ab
One week after full bloom+ 0ppm B	1.00 cd	1.04 bc	19.44 b	19.78 c
One week after full bloom+250ppm B	1.11 a	1.16 a	21.00 a	21.56 ab
One week after full bloom+500ppm B	1.09 ab	1.12 a	20.78 a	20.89 b
Two weeks after full bloom+ 0ppm B	0.98 d	1.03 c	19.11 b	19.78 c
Two weeks after full bloom+ 250ppm B	1.09 ab	1.15 a	20.89 a	21.33 ab
Two weeks after full bloom+ 500ppm B	1.08 a-c	1.11 ab	20.44 a	20.89 b
Effect of interaction between zinc and Boron				
0 ppm Zn + 0 ppm B	0.95 e	1.01 f	18.89 f	19.33 e
0 ppm Zn +25 0 ppm B	1.03 c-e	1.11 b-e	20.22 c-e	20.67 cd
0 ppm Zn + 500 ppm B	1.05 cd	1.07 c-f	20.00 c-e	20.33 c-e
250 ppm Zn + 0 ppm B	1.00 de	1.03 ef	19.33 ef	19.89 de
250 ppm Zn + 250 ppm B	1.10 a-c	1.14 bc	20.78 bc	21.11 bc
250 ppm Zn + 5000 ppm B	1.08 b-d	1.12 b-d	20.56 b-d	20.89 b-d
500 ppm Zn + 0 ppm B	1.03 c-e	1.06 d-f	19.78 d-f	20.11 c-e
500 ppm Zn + 250 ppm B	1.19 a	1.25 a	22.11 a	23.11 a
500 ppm Zn + 500 ppm B	1.14 ab	1.18 b	21.22 ab	21.78 b

Effect of application dates, zinc and Boron

Application dates	Zn (PPM)	B (PPM)	Shoot length (m)		No. of leaves per shoot	
			2017	2018	2017	2018
Full bloom	0	0	0.98 g-i	1.02 fg	19.33 e-g	19.33 g
Full bloom	0	250	1.03 c-i	1.12 b-g	20.33 c-f	21.00 c-g
Full bloom	0	500	1.05 b-i	1.07 d-g	20.00 c-g	20.33 e-g
Full bloom	250	0	1.01 e-i	1.03 e-g	19.33 e-g	20.00 e-g
Full bloom	250	250	1.11 a-g	1.14 b-f	21.00 a-d	21.33 b-f
Full bloom	250	500	1.09 a-h	1.13 b-g	20.33 c-f	21.00 c-g
Full bloom	500	0	1.04 b-i	1.06 d-g	19.67 d-g	20.00 e-g
Full bloom	500	250	1.21 a	1.30 a	22.33 a	23.67 a
Full bloom	500	500	1.16 a-d	1.21 a-c	21.33 a-c	22.33 a-d
One week after full bloom	0	0	0.95 hi	1.02 fg	18.67 g	19.33 g
One week after full bloom	0	250	1.04 b-i	1.11 b-g	20.33 c-f	20.67 d-g
One week after full bloom	0	500	1.05 b-i	1.07 d-g	20.33 c-f	20.33 e-g
One week after full bloom	250	0	1.01 e-i	1.04 e-g	19.67 d-g	19.67 fg
One week after full bloom	250	250	1.11 a-g	1.13 b-g	20.67 b-e	21.00 c-g
One week after full bloom	250	500	1.08 a-h	1.12 b-g	20.67 b-e	20.67 d-g
One week after full bloom	500	0	1.04 b-i	1.06 d-g	20.00 c-g	20.33 e-g
One week after full bloom	500	250	1.18 ab	1.23 ab	22.00 ab	23.00 ab
One week after full bloom	500	500	1.14 a-e	1.17 a-d	21.33 a-c	21.67 b-e
Two weeks after full bloom	0	0	0.93 i	1.00 g	18.67 g	19.33 g
Two weeks after full bloom	0	250	1.03 c-i	1.09 c-g	20.00 c-g	20.33 e-g
Two weeks after full bloom	0	500	1.04 b-i	1.07 d-g	19.67 d-g	20.33 e-g
Two weeks after full bloom	250	0	0.99 f-i	1.03 e-g	19.00 fg	20.00 e-g
Two weeks after full bloom	250	250	1.09 a-h	1.13 b-g	20.67 b-e	21.00 c-g
Two weeks after full bloom	250	500	1.07 a-i	1.12 b-g	20.67 b-e	21.00 c-g
Two weeks after full bloom	500	0	1.03 c-i	1.05 d-g	19.67 d-g	20.00 e-g
Two weeks after full bloom	500	250	1.17 a-c	1.24 ab	22.00 ab	22.67 a-c
Two weeks after full bloom	500	500	1.13 a-f	1.15 b-e	21.00 a-d	21.33 b-f

Means within each column for each interaction followed by the same letter (s) are not significantly at 5% level.

3.1.5. Weight of pruning wood (kg) per vine

It is clear from Fig. (5) that three application dates failed to induce any significant effect on weight of pruning wood (kg) per vine in both seasons. Moreover, 500 ppm zinc foliar spray vines resulted in increasing weight of pruning wood (kg) per vine as compared with other treatments in both seasons. Furthermore, 250 ppm B foliar spray in first season and 250 ppm or 500 ppm B foliar spray in the second gave similar effect and recorded the highest values of weight of pruning wood (kg) per vine in this respect.

On the other hand data of table (5), show clearly that the interaction between application dates and foliar spray with zinc reveals that 500 ppm zinc foliar spray at full bloom exerted the highest positive effect on weight of pruning wood (kg) per vine in both seasons. In addition, the combination between application dates and foliar spray with boron reveals that the combination of 250 ppm boron foliar spray at full bloom induced the highest positive effect on weight of pruning wood (kg) per vine as compared with other combinations in both seasons. Combination of foliar spray with Zn at 500 ppm plus B at 250 ppm improved weight of pruning wood (kg) per vine as compared with other combinations in both seasons.

Finally, the interaction among the three studied factors indicates that the interactions of 500 ppm Zn plus 250 ppm B foliar spray at full bloom surpassed the other combinations in improving weight of pruning wood (kg) per vine as compared with other combinations in both seasons.

3.1.6. Yield (kg)/kg pruning

It is clear from Fig. (6) that three application dates failed to induce any significant effect on Yield (kg)/kg pruning in both seasons. Moreover, 500 ppm zinc foliar spray vines resulted in increasing Yield (kg)/kg pruning as compared with other treatments in both seasons. Furthermore, 250 ppm B foliar spray recorded the highest values of Yield (kg)/kg pruning in both seasons.

On the other hand table (5) show that, the interaction between application dates and foliar spray with zinc reveals that 500 ppm zinc foliar spray at any of application dates exerted the similar effect and the highest positive effect on Yield (kg)/kg pruning in this respect. In addition, the combination between application dates and foliar spray with boron reveals that the combination of 250 ppm boron foliar spray at full bloom induced the highest positive effect on Yield (kg)/kg pruning as compared with other combinations in first season and 250 ppm and/or 500 ppm B foliar spray at any of application dates in the second season gave similar effect and recorded the highest values of Yield (kg)/kg pruning in this respect. Furthermore, foliar spray with zinc at 500 ppm associated with boron at 250 ppm or 500 ppm exerted the highest positive effect on Yield (kg)/kg pruning as compared with other combinations in both seasons.

The interaction among the three studied factors indicates that the interactions of 500 ppm Zn + 250 ppm B foliar spray at full bloom in both seasons and 500 ppm Zn + 250 ppm B foliar spray at one week after full bloom in second season gave similar effect and surpassed the other combinations in enhancing Yield (kg)/kg pruning as compared with other combinations.

The obtained results of zinc and / or boron and / or application dates as well as their combinations on vegetative growth are in harmony with the findings of Abou-Zaid and Shaaban (2019) they showed that spraying "Red Roomy" grapevines with zinc at 100 ppm significantly increased leaf area and shoot length as compared with the control. And that confirmed Belal *et al.,* (2023) they indicated that foliar application with Nano-zinc oxide significant increase leaf area, shoot length, number of leaves/shoot, Weight of pruning wood and chlorophyll contents of ‘Early Sweet’ grapevines. Also, (Hegazy *et al.,* (2018) they confirmed single or combined application of chelated- Zn at 0.05% and boric acid of 0.05% significantly stimulated main shoot length and the leaf area of Thompson seedless grapevines compared with check treatment. The enhancement effect of zinc on vegetative growth may be attributed that zinc has an important role in helpful for protein synthesis which enhances plant growth, also plays an important role in the assimilation of auxins that increase cell division and elongation by aiding the synthesis of nucleic acids such as tryptophan which is a major component of IAA that necessary for cell division and elongation as well as enhancing vegetative growth (Castillo-Gonzalez *et al.,* 2018). Castro *et al.* (2021) found that zinc treatments stimulated the leaf growth in all grape varieties (‘Donzelinho Branco’, ‘Verdelho’ and ‘Bastardo’). Furthermore, Bilir Ekbic *et al*. (2018) reported that Chlorophyll contents and leaf area increased with increasing boron treatments. Elbotaty (2007) found the same result on Crimson grapevines.

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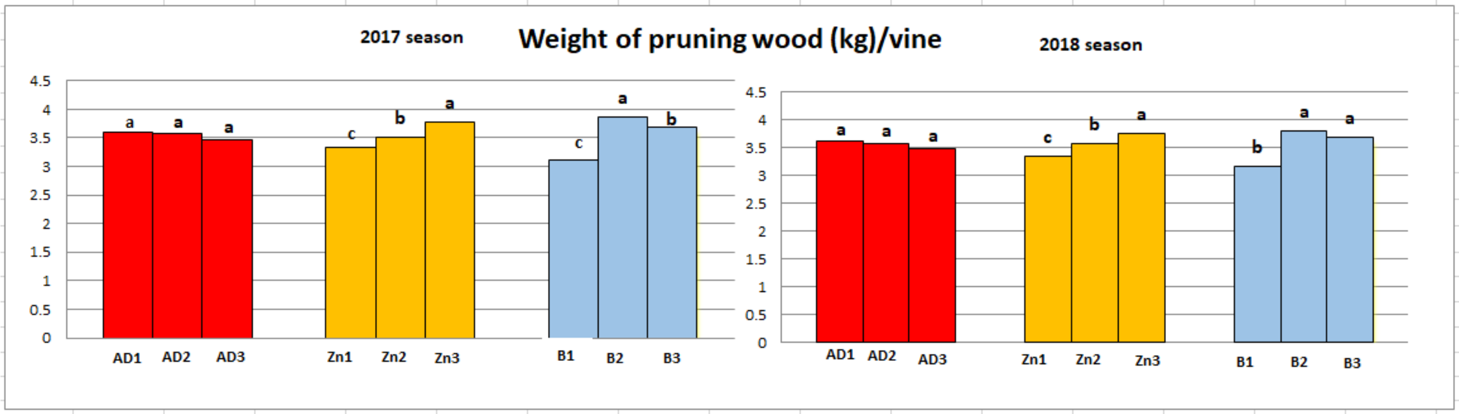

Fig. 5: Effect of application dates (AD), foliar spray of Zn and B on weight of pruning wood (kg)of "Early Sweet" grapes during 2017 and 2018 seasons.

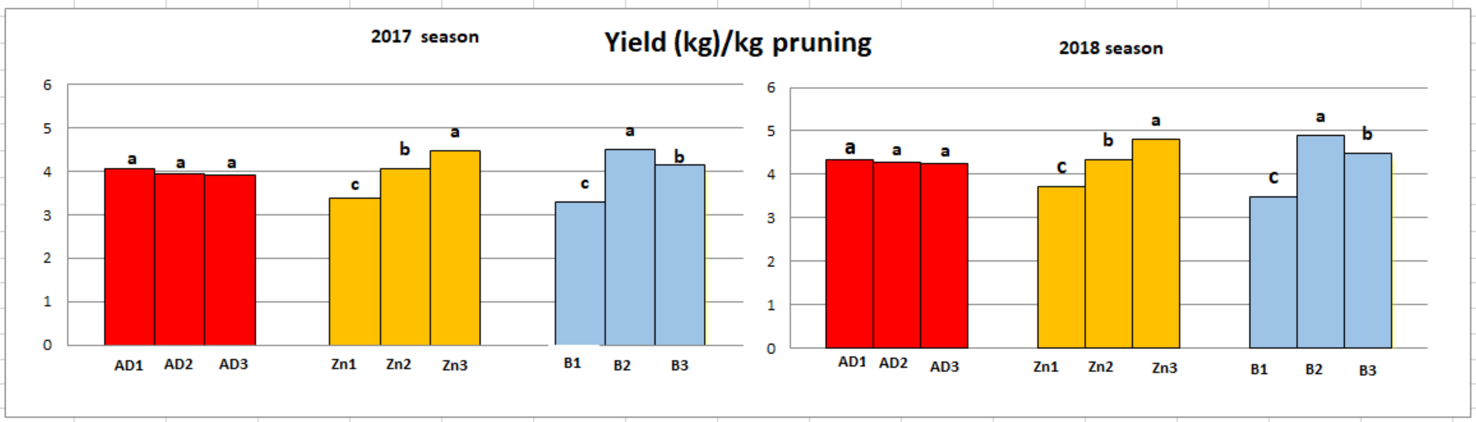

Fig. 6: Effect of application dates (AD), foliar spray of Zn and B on Yield (kg)/kg pruning of "Early Sweet" grapes during 2017 and 2018 seasons.

AD1 = Full bloom	**AD2** = One week after full bloom	**AD 3** = Two weeks after full bloom
Zn1 = 0 ppm Zn	**Zn2** = 250 ppm Zn	**Zn 3** = 500 ppm Zn
B1 = 0 ppm B	**B2** = 250 ppm B	**B 3** = 500 ppm B

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Table 5: Effect of interactions among application dates, foliar spray of Zn and B on weight of pruning wood (kg) per vine and Yield (kg)/kg pruning of "Early Sweet" grapes during 2017 and 2018 seasons.

Treatments	Weight of pruning wood (kg)		Yield (kg) /kg pruning	
	2017	2018	2017	2018
Effect of interaction between application dates and zinc				
Full bloom + 0ppm Zn	3.38 cd	3.44 de	3.48 cd	3.81 c
Full bloom +250ppm Zn	3.54 bc	3.61 a-d	4.22 ab	4.37 ab
Full bloom + 500 ppm Zn	3.88 a	3.82 a	4.48 a	4.82 a
One week after full bloom+ 0ppm Zn	3.38 cd	3.39 de	3.34 d	3.70 c
One week after full bloom+250ppm Zn	3.53 bc	3.57 b-d	4.05 ab	4.33 ab
One week after full bloom+500ppm Zn	3.80 a	3.76 ab	4.40 ab	4.81 a
Two weeks after full bloom+ 0ppm Zn	3.27 d	3.23 e	3.34 d	3.59 c
Two weeks after full bloom+ 250ppm Zn	3.48 b-d	3.52 cd	3.95 bc	4.31 b
Two weeks after full bloom+ 500ppm Zn	3.66 ab	3.68 a-c	4.49 a	4.82 a
Effect of interaction between application dates and Boron				
Full bloom + 0ppm B	3.16 c	3.25 b	3.33 c	3.50 b
Full bloom +250ppm B	3.92 a	3.89 a	4.63 a	4.89 a
Full bloom + 500 ppm B	3.72 ab	3.73 a	4.23 b	4.61 a
One week after full bloom+ 0ppm B	3.12 c	3.23 b	3.29 c	3.44 b
One week after full bloom+250ppm B	3.90 ab	3.77 a	4.39 ab	4.95 a
One week after full bloom+500ppm B	3.68 ab	3.71 a	4.11 b	4.45 a
Two weeks after full bloom+ 0ppm B	3.03 c	3.00 b	3.26 c	3.51 b
Two weeks after full bloom+ 250ppm B	3.76 ab	3.76 a	4.43 ab	4.87 a
Two weeks after full bloom+ 500ppm B	3.63 b	3.67 a	4.07 b	4.35 a
Effect of interaction between zinc and Boron				
0 ppm Zn + 0 ppm B	2.98 f	2.87 f	3.09 d	3.35 f
0 ppm Zn +25 0 ppm B	3.56 cd	3.65 b-d	3.71 bc	4.05 de
0 ppm Zn + 500 ppm B	3.48 de	3.54 cd	3.37 cd	3.71 ef
250 ppm Zn + 0 ppm B	3.12 f	3.18 e	3.36 cd	3.58 ef
250 ppm Zn + 250 ppm B	3.77 bc	3.81 a-c	4.81 a	5.00 bc
250 ppm Zn + 5000 ppm B	3.65 b-d	3.71 a-d	4.04 b	4.44 cd
500 ppm Zn + 0 ppm B	3.21 ef	3.43 de	3.44 cd	3.53 ef
500 ppm Zn + 250 ppm B	4.24 a	3.97 a	4.94 a	5.66 a
500 ppm Zn + 500 ppm B	3.89 b	3.86 ab	5.00 a	5.26 ab

Effect of application dates, zinc and Boron

Application dates	Zn (PPM)	B (PPM)	Weight of pruning wood (kg)		Yield (kg)/kg pruning	
			2017	2018	2017	2018
Full bloom	0	0	3.03 jk	3.09 fg	3.20 fg	3.35 h
Full bloom	0	250	3.57 c-h	3.66 b-d	3.87 d-f	4.14 d-h
Full bloom	0	500	3.52 d-i	3.57 b-f	3.38 e-g	3.94 e-h
Full bloom	250	0	3.14 h-k	3.25 d-g	3.40 e-g	3.54 gh
Full bloom	250	250	3.79 c-e	3.84 sb	4.98 a	5.04 a-d
Full bloom	250	500	3.68 c-f	3.74 a-d	4.28 b-d	4.54 b-g
Full bloom	500	0	3.30 f-k	3.41 b-g	3.39 e-g	3.62 gh
Full bloom	500	250	4.39 a	4.17 a	5.04 a	5.49 ab
Full bloom	500	500	3.95 a-d	3.87 ab	5.02 a	5.35 a-c
One week after full bloom	0	0	3.04 jk	2.98 gh	3.04 g	3.41 h
One week after full bloom	0	250	3.57 c-h	3.66 b-d	3.63 d-g	4.09 d-h
One week after full bloom	0	500	3.52 d-i	3.52 b-f	3.35 e-g	3.60 gh
One week after full bloom	250	0	3.14 h-k	3.14 e-g	3.35 e-g	3.57 gh
One week after full bloom	250	250	3.79 c-e	3.82 ab	4.80 ab	4.96 a-f
One week after full bloom	250	500	3.66 c-g	3.74 a-d	3.98 c-e	4.47 b-g
One week after full bloom	500	0	3.20 g-k	3.58 b-f	3.46 e-g	3.35 h
One week after full bloom	500	250	4.33 ab	3.84 ab	4.75 ab	5.80 a
One week after full bloom	500	500	3.87 b-e	3.87 ab	5.00 a	5.27 a-c
Two weeks after full bloom	0	0	2.87 k	2.55 h	3.03 g	3.29 h
Two weeks after full bloom	0	250	3.52 d-i	3.63 b-e	3.62 d-g	3.91 f-h
Two weeks after full bloom	0	500	3.41 e-j	3.52 b-f	3.37 e-g	3.58 gh
Two weeks after full bloom	250	0	3.09 i-k	3.14 e-g	3.31 e-g	3.61 gh
Two weeks after full bloom	250	250	3.74 c-f	3.77 a-c	4.66 a-c	4.99 a-e
Two weeks after full bloom	250	500	3.63 c-g	3.66 b-d	3.87 d-f	4.32 c-h
Two weeks after full bloom	500	0	3.14 h-k	3.30 c-g	3.46 e-g	3.61 gh
Two weeks after full bloom	500	250	4.01 a-c	3.90 ab	5.03 a	5.70 a
Two weeks after full bloom	500	500	3.85 c-e	3.84 ab	4.97 a	5.15 a-d

Abou-Zaid and Shaaban (2019) demonstrated that foliar spray boron at 40 ppm increased leaf area and shoot length of "Red Roomy" grapes. The enhancement effect of boron on vegetative growth may be attributed that boron simulated effect on cell division in meristematic tissues (Fawzi *et al.,* 2014). Also, Abou-Zaid and Shaaban (2019) they found that Spraying "Red Roomy" grapevines with Spirulina + zinc + boron gave the maximum values of leaf area and shoot length. El Gammal (2022) mentioned that foliar application of zinc and/or boric acid significantly increased vegetative growth, i.e. leaf area of olive. However, Walli *et al.* (2022) indicated that foliar application of boric acid and zinc sulfate (alone or in combination) particularly at all three phonological Stages of fruit growth i.e., full bloom, fruit set and premature stage have significantly enhanced the vegetative growth i.e. leaf area in Sweet Orange.

3.2. Yield (kg/vine)

3.2.1. Number of clusters per vine

Fig. (7) indicates that in first seasons, number of clusters per vine of application date (full bloom) foliar spray vines gave the highest values, but the three studied application dates i.e. full bloom, one week after full bloom and two weeks after full bloom exerted statistically similar effect on number of clusters per vine in the second season. Moreover, 500 ppm zinc foliar spray vines gave the highest positive effect on number of clusters per vine than other treatments in both seasons. Furthermore, 250 ppm B foliar spray gave the highest number of clusters per vine in both seasons in this respect.

Table (6) show that the interaction between application dates and foliar spray with zinc reveals that 500 ppm zinc foliar spray at full bloom gave the highest positive effect on number of clusters per vine in both seasons. In addition, the interaction between application dates and foliar spray with boron reveals that the combination of 250 ppm B foliar spray at full bloom induced high positive effect on number of cluster per vine as compared with other combinations in both seasons. Combination of 500 ppm Zn plus 250 ppm B foliar spray gave the highest positive effect on number of clusters per vine as compared with other combinations in both seasons.

Finally, the interaction among the three studied factors indicates that the interactions of 500 ppm Zn plus 250 ppm B foliar spray at full bloom surpassed the other combinations in improving number of clusters per vine as compared with other combinations in both seasons.

3.2.2. Yield (kg/vine)

Fig. (8) reveals that in first seasons, application date (full bloom) foliar spray vines gave the highest enhanced effect on yield, but in the second season, the three studied application dates i.e. full bloom, one week after full bloom and two weeks after full bloom had no significant effect in enhancing yield. Moreover, 500 ppm zinc foliar spray vines resulted in increasing vine yield as compared with other treatments in both seasons. Furthermore, 250 ppm B foliar spray recorded the highest values of vine yield in both seasons in this respect.

Table (6) indicates that the interaction between application dates and foliar spray with zinc reveals that in both seasons, 500 ppm zinc foliar spray at full bloom, 500 ppm zinc foliar spray at one week after full bloom, 500 ppm zinc foliar spray at two weeks after full bloom gave the similar effect and the highest yield vines. In addition, the interaction between application dates and foliar spray with boron reveals that the combination of 250 ppm B foliar spray at full bloom or one week after full bloom increased yield vines as compared with other combinations in both seasons. Combination of foliar spray with Zn at 500 ppm plus B at 250 ppm improved vine productivity as compared with other combinations in both seasons.

Finally, the interaction among the three studied factors indicates that the interactions of 500 ppm Zn plus 250 ppm B foliar spray at all application dates gave similar and surpassed the other combinations in enhancing yield as compared with other combinations in both seasons.

The obtained results of zinc and / or boron and or application dates as well as their combinations on yield go on line with the finding of Song *et al.,* 2015; Güneş *et al.* (2015); Abou-Zaid and Shaaban (2019) and Swathi *et al.,* (2019) they reported that zinc foliar spray increment yield of grapevine. Usha and Singh (2002) found that boron sprays improving the yield of ‘Perlette’ grape. In addition, Bilir Ekbic *et al.,* (2018) showed that boric acid treatments at two different periods (a week before and after full-bloom) positively effect on yield of "Isabella" grape. Nyomora *et al.* (1999) found that rate of B concentrations and time application of boron had significant effects on yield of almond trees.

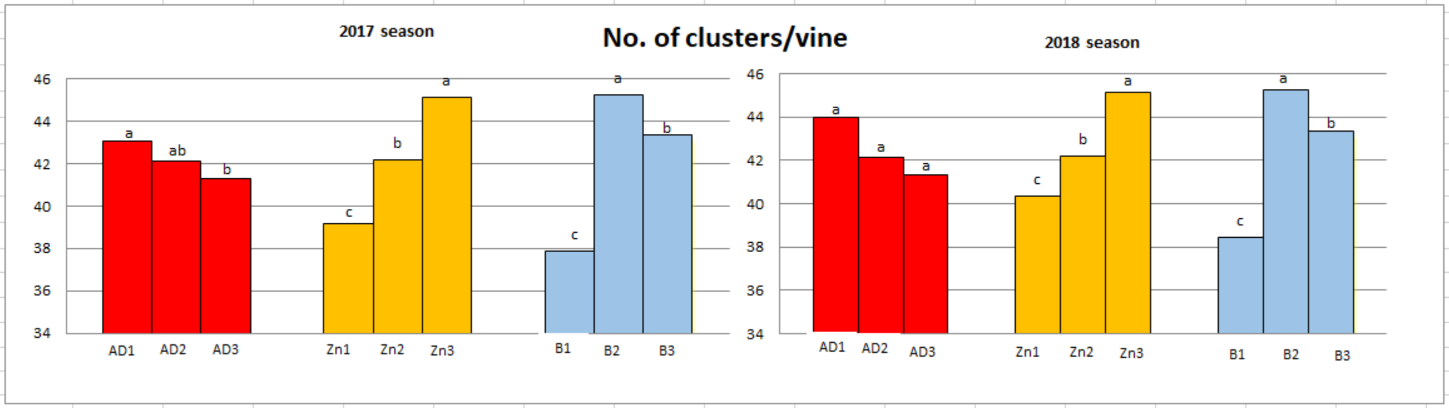

Fig. 7: Effect of application dates (AD), foliar spray of Zn and B on number of clusters per vine of "Early Sweet" grapes during 2017 and 2018 seasons.

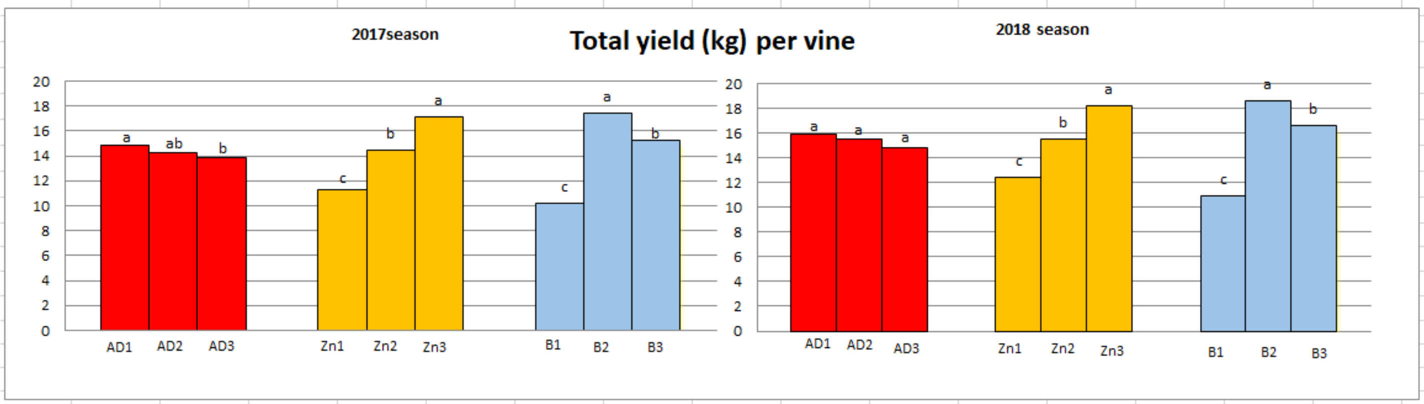

Fig. 8: Effect of application dates (AD), foliar spray of Zn and B on total yield (kg) per vine of "Early Sweet" grapes during 2017 and 2018 seasons.

AD1 = Full bloom	**AD2** = One week after full bloom	**AD 3** = Two weeks after full bloom
Zn1 = 0 ppm Zn	**Zn2** = 250 ppm Zn	**Zn 3** = 500 ppm Zn
B1 = 0 ppm B	**B2** = 250 ppm B	**B 3** = 500 ppm B

Table 6: Effect of interactions among application dates, foliar spray of Zn and B on number of clusters per vine and total yield per vine of "Early Sweet" grapes during 2017 and 2018 seasons.

Treatments	No. of clusters/vine		Yield (kg/vine)	
	2017	2018	2017	2018
Effect of interaction between application dates and zinc				
Full bloom + 0ppm Zn	40.00 c-e	41.33 c-e	11.76 c	13.14 de
Full bloom +250ppm Zn	43.11 a-c	43.78 bc	15.02 b	15.89 bc
Full bloom + 500 ppm Zn	46.11 a	46.78 a	17.68 a	18.63 a
One week after full bloom+ 0ppm Zn	39.44 de	40.67 de	11.30 c	12.55 e
One week after full bloom+250ppm Zn	42.22 b-d	43.67 bc	14.42 b	15.61 c
One week after full bloom+500ppm Zn	44.78 ab	46.00 ab	16.96 a	18.22 a
Two weeks after full bloom+ 0ppm Zn	38.11 e	39.00 e	10.91 c	11.67 e
Two weeks after full bloom+ 250ppm Zn	41.22 c-e	42.44 cd	13.86 b	15.09 cd
Two weeks after full bloom+ 500ppm Zn	44.56 ab	45.56 ab	16.67 a	17.74 ab
Effect of interaction between application dates and Boron				
Full bloom + 0ppm B	38.56 d	39.33 d	10.47 e	11.35 e
Full bloom +250ppm B	46.67 a	47.22 a	18.23 a	19.09 a
Full bloom + 500 ppm B	44.00 bc	45.33 a-c	15.77 cd	17.22 b-d
One week after full bloom+ 0ppm B	38.00 d	38.78 d	10.25 e	11.10 e
One week after full bloom+250ppm B	45.00 ab	46.78 ab	17.24 ab	18.70 ab
One week after full bloom+500ppm B	43.44 bc	44.78 bc	15.19 d	16.57 cd
Two weeks after full bloom+ 0ppm B	37.11 d	37.22 d	9.84 e	10.42 e
Two weeks after full bloom+ 250ppm B	44.11 bc	45.67 a-c	16.74 bc	18.05 a-c
Two weeks after full bloom+ 500ppm B	42.67 c	44.11 c	14.86 d	16.03 d
Effect of interaction between zinc and Boron				
0 ppm Zn + 0 ppm B	36.56 f	36.44 h	9.12 h	9.56 g
0 ppm Zn +25 0 ppm B	41.00 cd	43.00 de	13.17 e	14.73 d
0 ppm Zn + 500 ppm B	40.00 de	41.56 ef	11.69 f	13.07 e
250 ppm Zn + 0 ppm B	38.11 ef	38.56 gh	10.44 g	11.24 f
250 ppm Zn + 250 ppm B	45.67 b	46.56 bc	18.13 c	18.89 b
250 ppm Zn + 5000 ppm B	42.78 c	44.78 cd	14.73 d	16.46 c
500 ppm Zn + 0 ppm B	39.00 de	40.33 fg	10.99 fg	12.07 ef
500 ppm Zn + 250 ppm B	49.11 a	50.11 a	20.91 a	22.23 a
500 ppm Zn + 500 ppm B	47.33 ab	47.89 ab	19.41 b	20.28 b

Effect of application dates, zinc and Boron

Application dates	Zn (PPM)	B (PPM)	No. of clusters/vine		Yield (kg/vine)	
			2017	2018	2017	2018
Full bloom	0	0	38.00 h-j	38.00 j	9.61 l-n	10.24 no
Full bloom	0	250	41.67 e-g	43.67 c-g	13.84 f-h	15.11 h-j
Full bloom	0	500	40.33 f-i	42.33 e-i	11.84 h-k	14.07 i-m
Full bloom	250	0	38.33 g-i	39.00 h-j	10.65 j-n	11.47 mn
Full bloom	250	250	47.00 bc	47.00 a-d	18.76 b-d	19.32 c-e
Full bloom	250	500	44.00 c-e	45.33 b-f	15.67 ef	16.89e-h
Full bloom	500	0	39.33 f-i	41.00 g-j	11.16 i-m	12.34 k-n
Full bloom	500	250	51.33 a	51.00 a	22.08 a	22.85 a
Full bloom	500	500	47.67 b	48.33 ab	19.80 bc	20.70 a-d
One week after full bloom	0	0	37.00 ij	37.67 jk	9.20 mn	10.09 no
One week after full bloom	0	250	41.00 e-h	43.00 d-h	18.21 cd	14.91 h-k
One week after full bloom	0	500	40.33 f-i	41.33 f-j	11.75 h-l	12.66 j-n
One week after full bloom	250	0	38.00 h-j	38.67 ij	10.56 j-n	11.22 n
One week after full bloom	250	250	46.00 b-d	47.00 a-d	18.21 cd	18.94 d-f
One week after full bloom	250	500	42.67 d-f	45.33 b-f	14.49 fg	16.67 f-i
One week after full bloom	500	0	39.00 g-i	40.00 g-j	10.98 i-m	12.00 l-n
One week after full bloom	500	250	48.00 ab	50.33 a	20.57 ab	22.26 ab
One week after full bloom	500	500	47.33 bc	47.67 a-c	19.35 b-d	20.39 a-d
Two weeks after full bloom	0	0	34.67 j	33.67 k	8.56 n	8.35 o
Two weeks after full bloom	0	250	40.33 f-i	42.33 e-i	12.69 g-j	14.16 i-l
Two weeks after full bloom	0	500	39.33 f-i	41.00 g-j	11.48 i-l	12.50 j-n
Two weeks after full bloom	250	0	38.00 h-j	38.00 j	10.13 k-n	11.03 n
Two weeks after full bloom	250	250	44.00 c-e	45.67 b-e	17.42 de	18.43 d-g
Two weeks after full bloom	250	500	41.67 e-g	43.67 c-g	14.03 fg	15.82 g-i
Two weeks after full bloom	500	0	38.67 g-i	40.00 g-j	10.84 i-m	11.88 l-n
Two weeks after full bloom	500	250	48.00 ab	49.00 ab	20.09 a	21.57 a-c
Two weeks after full bloom	500	500	47.00 bc	47.67 a-c	19.07 b-d	19.76 b-d

Means within each column for each interaction followed by the same letter (s) are not significantly at 5% level.

Moreover, Nikkhah *et al.* (2013) reported that foliar sprays of boron and zinc improved the yield of eight different grapevine cultivars. Similar yield improvement due to Zn and / or B spray in vine was reported by Prabu and Singaram, (2002) they mentioned that combination foliar application ZnSO4 at 0.5 % plus borax at 0.2 % applied at twice during vegetative (20 days after pruning) and full bloom stages excelled others by having more yield, the increase in yield in case of Zn and B treated vines may be due to the fact that in these vines fruit set was more and berry drop was less.

On another hand, Hegazy *et al*. (2018) found that single or combined application of chelated –Zn and boric acid had no significant effect on the number of clusters per vine of Thompson seedless grapevines in the first season of study and significantly improved the yield expressed in weight and number of clustered per vine (in the second season) rather than the check treatment.

4. Conclusion

To conclude, in this study, it have used applications such as foliar spray of zinc and boron either individually or combined, at different application dates, to enhance the vegetative growth and yield of ‘Early Sweet’ grapevines. The results demonstrated that the interactions of 500 ppm Zn plus 250 ppm B foliar spray at full bloom surpassed the other combinations in enhancing the vegetative growth i.e., Leaf area, Leaf total chlorophyll content, Shoot length, number of leaves per Shoot and weight of pruning wood as well as increasing yield. Therefore, it is recommended to apply foliar spray with Zn at 500 ppm plus foliar spray with B at 250 ppm once at full bloom stage on ‘Early Sweet’ grapevines under Egyptian conditions.

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