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Effect of Zinc and Boron on Fruit Quality of Early Sweet Grape under Desert Conditions

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ABSTRACT

The investigation studied the effects of zinc, boron, and spraying time on the marketability of Early Sweet (*Vitis vinifera* L.) table grape berries. The experiment was conducted over the course of two consecutive seasons in 2017 and 2018 on Early Sweet vines grown in sandy soil under drip irrigation in a private vineyard located in the Giza governorate, Egypt. Furthermore, as compared to untreated berries, all investigated treatments considerably enhanced the quality of the berries in terms of increased weight, total soluble solids, and total acidity reduction. Vine plants sprayed with 500 ppm zinc and 250 ppm zinc oxide at full bloom had the best results. It was determined that annual spraying of Zn at 500 ppm and B at 250 ppm was required to get satisfactory cluster.

Keywords: zinc, boron, Early Sweet grapevines, fruit quality.

1. Introduction

Early sweet grapevine cultivar 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 shot berries formation and clusters compactness (Abdel Rehim *et al.,* 2022; Or *et al.,* 2020 and Belal *et al.,* 2023). Also, producing high-quality table grapes is becoming a challenge in the warmer area of the world, such as in Egypt, due to the global increase in temperature, which negatively affects fruit quality attributes (Abou El-Nasr *et al.,* 2021). Cameron *et al.* (2021) suggests that the response of phenological stage to temperature is not linear and varies between grape cultivars. Sarwar *et al.* (2022) reported that foliar sprays of Zn and B alleviated adverse effects of high-temperature stress cotton. On the other hand, Parthenocarpic fruit development was associated with deficiency in essential micronutrients such as B and Zn (Vasconcelos *et al.,* 2009). In a study on eight grape cultivars Nikkhah *et al.* (2013) reported that different cultivars respond differently to application of B and Zn.

Zinc is required in small but critical concentration for the functioning of several plants physiological like photosynthesis, sugar formation, nucleic acid metabolism, protein and carbohydrate biosynthesis (Baghdady *et al.,* 2014 and Jerlin *et al.,* 2017). It has an enzymatic and reactive function by involving in the catalytic function of the enzyme and zinc has binding sites wide range with other proteins, membrane lipids and DNA and carbohydrate translocation (Klug, 1999 and Englbrecht *et al.,* 2004). Zinc is a cofactor of over 300 enzymes and proteins and has an early and specific effect on cell division (Marschner, 1986). Zn deficiency effect on pollen production and pollen physiology (Usenik andStampar, 2002 and Ute and Clemens, 2005), it is closely involved in pollen tube growth resulted from its role on tryptophan synthesis as an auxin precursor biosynthesis (Alloway, 2004 and Hassan *et al.,* 2010). So, zinc deficiency reduces fruit-set and increase shot berries formation in grapes (Christensen and Peacock, 2000). Zinc deficiency is visually expressed as small leaves, delayed opening of vegetative and flower buds, wrinkle or waving leaves with upward folded leaf margins and terminal dieback (Ramos, 1997).

The main function of boron relate to cell wall strength and development, cell division, sugar transport and hormones development, RNA metabolism, respiration, and as part of the cell membranes (Camacho-Cristóbal *et al.,* 2008). It has been playing an essential role in fertility and increase pollen

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germination and pollen tube elongation in a number of tree species (Nyomora *et al.,* 1997 and Christensen *et al.,* 2006). Boron deficiency causes impact the production and quality of grapevine (Güneş *et al.,* 2015) and reduced pollen production and poor fruit set, small "shot berries" and flower and fruit cluster necrosis and have a drastic effect on fruit quality and yield (Christensen *et al.,* 2006). The suitable time of boron foliar spray is important and effective for blooming and fruit development (Masoud, 2017). Bilir Ekbic *et al.* (2018) mentioned that foliar 0.3% boric acid at two different periods (a week before and after full-bloom) were recommended for high quality and quantity yields of "Isabella" grapevine. The combination of foliar spray Spirulina 1%, zinc 50 ppm and boron 20 ppm applied at twice, one at the beginning of growth and second at the flowering period. it improved yield and berries quality of "Red Roomy" grapevines (Abou-Zaid and Shaaban, 2019).

It is important to determine fertilized factors, including fertilization amount and application time. The timing of fertilizer application depends on many factors including grape cultivar, phenology, nutrient mobility and cation exchange capacity. Application of zinc and boron are critical prior to flowering for good bud initiation for the following season and fruit set in the current season (Ashley, 2011). In study on 'Concord' grapevine reported that the results showed that seasonal patterns of micronutrient concentrations varied considerably with respect to growth stage. Leaf blades, shoot tips, and petioles had the highest concentration of B at bloom. Translocation of B from woody tissue to actively growing organs occurred at the beginning of the season. The majority of B uptake occurred between bloom and veraison when Zn concentrations in leaf blades and clusters were highest at bloom (Pradubsuk and Davenport 2011). On the other hand, (Christensen 1980) mentioned that foliar zinc sprays were applied to three trial vineyards cultivar Thompson Seedless at various intervals. The spring treatments started four weeks pre-bloom and continued to the fruit-set stage. Vine response as measured by fruit-set and development at harvest was maximum from sprays applied two weeks pre-bloom through full bloom. Some earlier and later spring treatments also responded, although degree and consistency were less. The fall sprays gave little or no response. Shaaban and El-Fouly (2012) reported that zinc deficiency can be corrected by applying zinc sprays before flowering and after fruit set. It's a rapid method to correct a deficiency of (Thompson Seedless and Early Superior) grapevine. In addition, certain foliar fertilizers applied at the proper time can stimulate metabolism in vines to enhance production and reduce stress and zinc foliar fertilization is an important element of modern vineyard management (Du *et al.,* 2014). Pre-harvest foliar application of variant Zn and B levels at different phenological stages of fruit growth and development, i.e., full bloom, fruit set and premature stage improve growth and quality of sweet orange. Concerning stage comparison, foliar application of Zn and B at fruit set biter than full bloom and premature stage. However, full bloom + fruit set + premature stage resulted in maximum production with high quality fruits (Walli *et al.* (2022). Mohamed *et al.* (2021) reported that spraying Early sweet grapevines grown under sandy soil three times at the beginning of growth (first week of March), just after berry setting (first week of April) and after three week (last week of April) with some micronutrients (Fe, Mn, Zn and Cu) at 0.025 to 0.1% was suggested for obtaining an economical yield and improving physical and chemical characteristics of the berries.

The purposes of this research were to study the effect of foliar zinc and boron and application dates alone and/or their combinations on fruit quality 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.

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 treatment of each factor was replicated three times and each replicate was represented by one plants. 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 ".

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.

2.1. Fruit physical properties

Representative random samples of 3 clusters per replicate were taken to the laboratory to determined cluster weight, cluster volume (cm^3), cluster dimensions (length and width), number of berries per cluster, cluster compactness coefficient, average number of berries per cluster was counted to determine clusters compactness using the following equation according to Ali *et al.* (2000). Cluster compactness coefficient = number of berries per cluster/ cluster length (cm). Shot berries percentage = (Number of shot berries per cluster/Total number of berries per cluster) X100. A random sample of 100 berries per each replication was taken to determine: Weight of 100 berries, berries length (cm) and berries width (cm).

2.2. Fruit chemical properties

Total soluble solids (T.S.S.) in berry juice was determined by Hand refractometer in (Brix), total acidity in berry juice (expressed as tartaric acid percentage) according to (A.O.A.C., 1995), TSS/ Acid ratio was calculated by divided TSS on acidity. L-ascorbic acid mg /100g was determined in berry juice by titration method using 2,6 Dichloro – phenol – indophenol as described in A.O.A.C (1995). The results were calculated as mg /100g fresh weight.

2.3. 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. Fruit physical properties

3.1.1. Cluster weight (g)

It is clear from Fig. (1) and Table (1) that three application dates failed to induce any significant effect on cluster weight in both seasons. Moreover, 500 ppm zinc foliar spray produced the highest value of cluster weight than other treatments. Furthermore, 250 ppm boron foliar spray increased cluster weight as compared with those treated vines.

On the other hand, the interaction between application dates and foliar spray with zinc reveals that the combinations of 500 ppm zinc foliar spray at full bloom in both seasons, 500 ppm zinc foliar spray at one week after full bloom in first season and 500 ppm zinc foliar spray at two weeks after full bloom in first season exerted the similar effect and the highest positive effect on cluster weight in this respect. In addition, the interaction between application dates and foliar spray with boron reveals that the combination of 250 ppm boron foliar spray at full bloom or at one week after full bloom in both seasons, 250 ppm boron foliar spray at two weeks after full bloom in the first season induced statistically similar and high positive effect on cluster weight as compared with other combinations in this respect. Furthermore, foliar spray with zinc at 500 ppm associated with boron at 250 ppm gave the highest positive effect on cluster weight as compared with other combinations in both seasons.

Finally, the interaction between the three studied factors indicates that the interactions of 500 ppm Zn + 250 ppm B foliar spray at full bloom and 500 ppm Zn + 250 ppm B foliar spray at one week after full bloom in the both seasons and 500 ppm Zn + 250 ppm B foliar spray at two weeks after full bloom in the second season gave similar effect and surpassed the other combinations in enhancing cluster weight as compared with other combinations.

Table 1: Effect of interactions among application dates, foliar spray of Zn and B on cluster weight (g) and cluster volume (cm^3) of "Early Sweet" grapes during 2017 and 2018 seasons.

Treatments	Cluster weight (g) 2017	Cluster weight (g) 2018	Cluster volume (cm^3) 2017	Cluster volume (cm^3) 2018
Effect of interaction between application dates and zinc				
Full bloom + 0ppm Zn	292.9 c	316.2 e	287.8 e	311.1 d
Full bloom +250ppm Zn	344.2 b	359.4 b-d	342.2 c	356.7 bc
Full bloom + 500 ppm Zn	376.2 a	391.4a	375.6 a	391.1 a
One week after full bloom+ 0ppm Zn	285.6 c	307.2e	282.2 e	300.6 d
One week after full bloom+250ppm Zn	337.6 b	353.9 cd	333.3 cd	351.1 c
One week after full bloom+500ppm Zn	372.8 a	390.2 ab	367.8 ab	385.0 ab
Two weeks after full bloom+ 0ppm Zn	284.4 c	295.4e	278.9 e	291.7 d
Two weeks after full bloom+ 250ppm Zn	332.8 b	351.3 d	328.9 d	347.2 c
Two weeks after full bloom+ 500ppm Zn	367.8 a	384.4 a-c	363.3 b	380.6 ab
Effect of interaction between application dates and Boron				
Full bloom + 0ppm B	271.1 c	288.4 d	270.0 c	285.6 d
Full bloom +250ppm B	387.8 a	401.3 a	385.6 a	397.8 a
Full bloom + 500 ppm B	354.4 b	377.3 a-c	350.0 b	375.6 a-c
One week after full bloom+ 0ppm B	269.1 c	286.2 d	266.7 c	283.9 d
One week after full bloom+250ppm B	380.3 a	397.9 a	375.6 a	391.7 a
One week after full bloom+500ppm B	346.4 b	367.2 bc	341.1 b	361.1 bc
Two weeks after full bloom+ 0ppm B	264.4 c	278.6 d	263.3 c	277.2 d
Two weeks after full bloom+ 250ppm B	376.1 a	391.9 ab	370.0 a	385.6 ab
Two weeks after full bloom+ 500ppm B	344.4 b	360.8 c	337.8 b	356.7 c
Effect of interaction between zinc and Boron				
0 ppm Zn + 0 ppm B	249.2 f	262.0 e	246.7 f	257.8 f
0 ppm Zn +25 0 ppm B	321.7 d	342.3 c	315.6 d	337.8 d
0 ppm Zn + 500 ppm B	292.0 e	314.6 d	286.7 e	307.8 e
250 ppm Zn + 0 ppm B	273.8 e	291.3 d	272.2 e	292.2 e
250 ppm Zn + 250 ppm B	396.9 b	405.4 b	392.2 b	398.3 b
250 ppm Zn + 5000 ppm B	343.9 c	367.9 c	340.0 c	364.4 c
500 ppm Zn + 0 ppm B	281.7 e	299.9 d	281.1 e	296.7 e
500 ppm Zn + 250 ppm B	425.7 a	443.3 a	423.3 a	438.9 a
500 ppm Zn + 500 ppm B	409.4 ab	422.9 ab	402.2 b	421.1 ab

Effect of application dates, zinc and Boron

Application dates	Zn (PPM)	B (PPM)	Cluster weight (g) 2017	Cluster weight (g) 2018	Cluster volume (cm^3) 2017	Cluster volume (cm^3) 2018
Full bloom	0	0	252.0 h-j	270.0 hi	246.7 i	266.7 lm
Full bloom	0	250	333.3 cd	347.0 ef	326.7 de	343.3 g-i
Full bloom	0	500	293.3 e-g	331.7 e-g	290.0 f-h	323.3 h-k
Full bloom	250	0	277.7 g-j	294.3 gh	280.0 gh	293.3 kl
Full bloom	250	250	400.0 ab	410.3 a-c	396.7 bc	406.7 a-e
Full bloom	250	500	355.0 c	373.7 b-e	350.0 d	370.0 d-g
Full bloom	500	0	283.7 f-h	301.0 gh	283.3 f-h	296.7 b-f
Full bloom	500	250	430.0 a	446.7 a	433.3 a	443.3 a
Full bloom	500	500	415.0 ab	426.7 a	410.0 a-c	433.3 a-c
One week after full bloom	0	0	249.0 ij	268.3 hi	246.7 i	261.7 lm
One week after full bloom	0	250	395.7 b	346.7 ef	313.3 ef	340.0 g-j
One week after full bloom	0	500	291.0 e-g	306.7 f-h	286.7 f-h	300.0 i-l
One week after full bloom	250	0	277.0 g-j	290.0 g-i	273.3 hi	293.3 kl
One week after full bloom	250	250	395.7 b	403.7 a-d	390.0 c	396.7 j-l
One week after full bloom	250	500	340.0 cd	368.0 c-e	336.7 de	363.3 e-h
One week after full bloom	500	0	281.3 gh	300.3 gh	280.0 gh	296.7 j-l
One week after full bloom	500	250	428.7 a	443.3 a	423.3 ab	438.3 ab
One week after full bloom	500	500	408.3 ab	427.0 a	400.0 bc	420.0 a-c
Two weeks after full bloom	0	0	246.7 j	247.7 i	246.7 i	245.0 m
Two weeks after full bloom	0	250	315.0 d-f	333.3 e-g	306.7 e-g	330.0 g-k
Two weeks after full bloom	0	500	291.7 e-g	305.3 f-h	283.3 f-h	300.0 i-l
Two weeks after full bloom	250	0	266.7 g-j	289.7 g-i	263.3 hi	290.0 kl
Two weeks after full bloom	250	250	395.0 b	402.3 a-d	390.0 c	391.7 c-f
Two weeks after full bloom	250	500	336.7 cd	362.0 de	333.3 de	360.0 f-h
Two weeks after full bloom	500	0	280.0 g-i	298.3 gh	280.0 gh	296.7 j-l
Two weeks after full bloom	500	250	418.3 ab	440.0 a	413.3 a-c	435.0 a-c
Two weeks after full bloom	500	500	405.0 ab	415.0 ab	396.7 bc	410.0 a-d

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

3.1.2. Cluster volume (cm^3)

Fig. (2) and table (1) shows that three application dates failed to exert any significant effect on cluster volume in both seasons. Moreover, 500 ppm zinc foliar spray produced the highest value of cluster volume than other treatments. Also, 250 ppm boron foliar spray improved cluster volume as compared with those treated and untreated vines.

On the other hand, the interaction between application dates and foliar spray with zinc reveals that combination of 500 ppm zinc foliar spray at full bloom increased cluster volume as compared with other treatments in both seasons. In addition, the interaction between application dates and foliar spray with boron reveals that the combination of 250 ppm boron foliar spray at full bloom and 250 ppm boron foliar spray at one week after full bloom in both seasons and 250 ppm boron foliar spray at two week after full bloom in in the first season gave similar effect and high positive effect on cluster volume as compared with other combinations in this respect. Furthermore, foliar spray with zinc at 500 ppm associated with boron at 250 ppm exerted the highest positive effect on cluster volume as compared with other combinations in both seasons.

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

3.1.3. Cluster length (cm)

It is clear from Fig. (3) and table (2) that three application dates had no significant effect on cluster length in both seasons. Zinc foliar spray at 500 ppm increased cluster length and surpassed other treatments. Boron foliar spray at 250 ppm in both seasons and Boron foliar spray at 500 ppm in the second season produced similar effect and the highest cluster length values as compared with those untreated vines.

On the other hand, 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 cluster length values 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 in both seasons, 500 ppm B foliar spray at full bloom in the second season, 250 ppm or 500 ppm B foliar spray at one week after full bloom in the second season and 250ppm or 500 ppm B foliar spray at two week after full bloom in the second season gave statistically similar and high positive effect on cluster length values as compared with other combinations in this respect. Zinc foliar spray at 500 ppm associated with boron at 250 ppm gave the highest positive effect on cluster length 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 cluster length as compared with other combinations.

3.1.4. Cluster width (cm)

It is clear from Fig. (4) and table (2) that three application dates had no significant effect on cluster width in both seasons. Moreover, 500 ppm zinc foliar spray produced the highest cluster width than other treatments. Furthermore, 250 ppm boron foliar spray in both season and 500 ppm boron foliar spray in the first season produced similar effect and the highest cluster width values as compared with those untreated vines.

On the other hand, 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 cluster width values 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 in both seasons, 500 ppm B foliar spray at full bloom in the first season, 250 ppm or 500 ppm B foliar spray at one week after full bloom in the first season, and 250 ppm or 500 ppm B foliar spray at two week after full bloom in the first season induced statistically similar and high positive effect on cluster width as compared with other combinations in this respect

Fig. 1: Effect of application dates (AD), foliar spray of Zn and B on cluster weight (g) of "Early Sweet" grapes during 2017 and 2018 seasons.

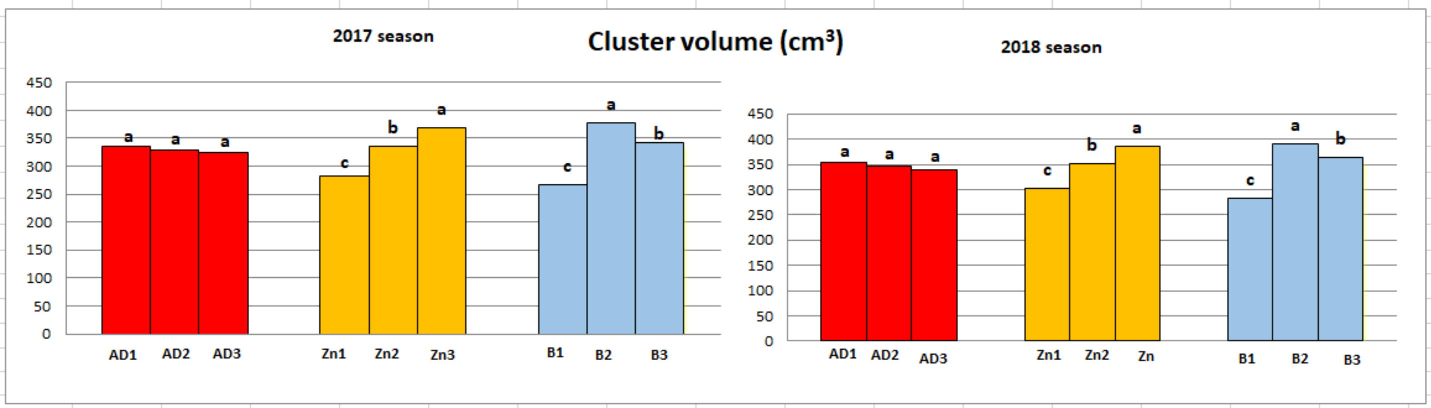

Fig. 2: Effect of application dates (AD), foliar spray of Zn and B on cluster volume (cm^3) of "Early Sweet" grapes during 2017 and 2018 seasons.

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

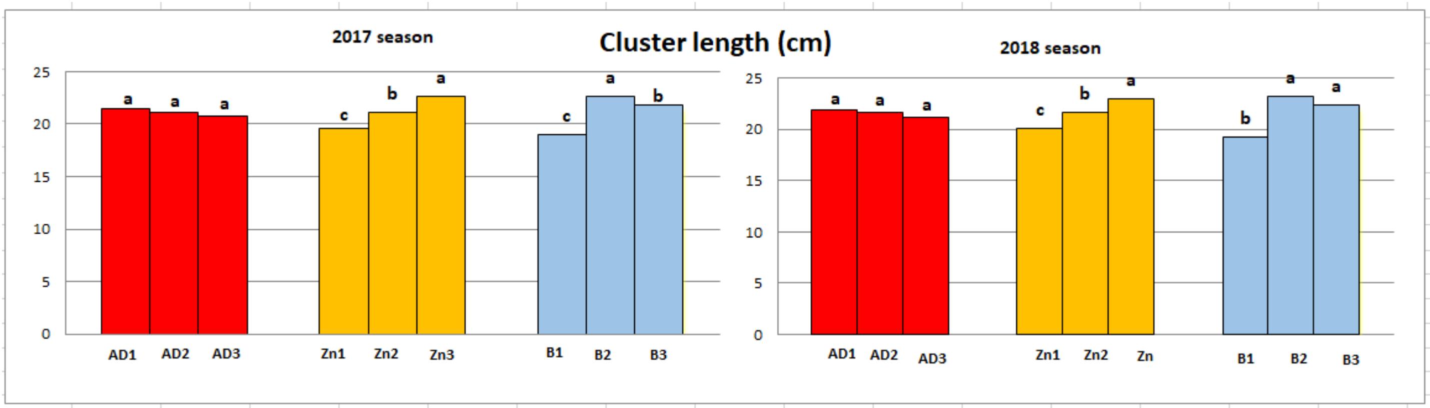

Fig. 3: Effect of application dates (AD), foliar spray of Zn and B on cluster length (cm)of "Early Sweet" grapes during 2017 and 2018 seasons.

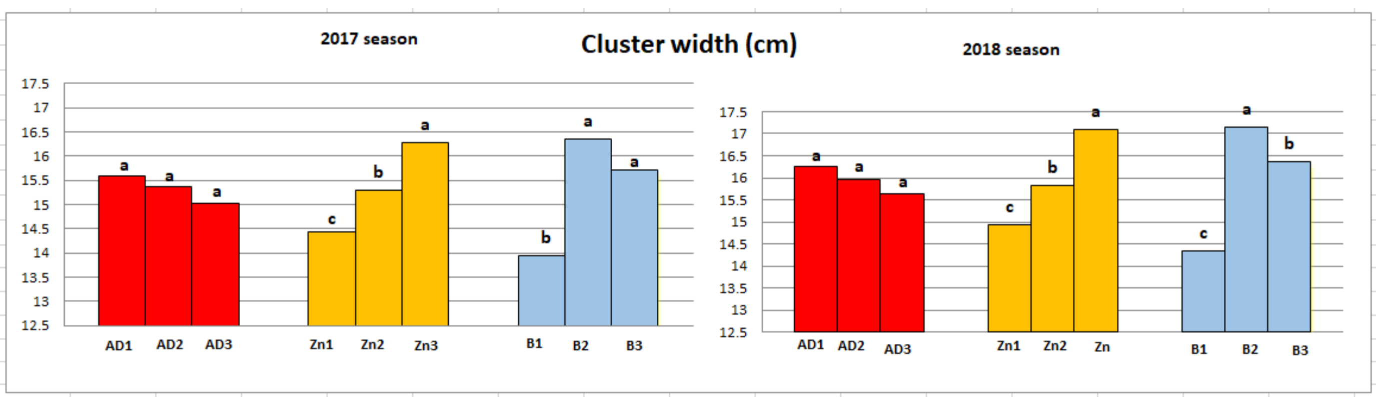

Fig. 4: Effect of application dates (AD), foliar spray of Zn and B on cluster width (cm) of "Early Sweet" grapes during 2017 and 2018 seasons.

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 2: Effect of interactions among application dates, foliar spray of Zn and B on cluster length (cm) and cluster width (cm) of "Early Sweet" grapes during 2017 and 2018 seasons.

Treatments	Cluster length (cm)		Cluster width (cm)	
	2017	2018	2017	2018
Effect of interaction between application dates and zinc				
Full bloom + 0ppm Zn	19.94 cd	20.62 c-e	14.76 d-f	15.23 de
Full bloom +250ppm Zn	21.52 a-c	21.84 bc	15.48 b-d	16.06 b-d
Full bloom + 500 ppm Zn	23.08 a	23.34 a	16.58 a	17.48 a
One week after full bloom+ 0ppm Zn	19.77 cd	20.33 de	14.54 ef	15.04 de
One week after full bloom+250ppm Zn	21.03 b-d	21.77 b-d	15.27 c-e	15.76 cd
One week after full bloom+500ppm Zn	22.48 ab	22.98 ab	16.26 ab	17.12 ab
Two weeks after full bloom+ 0ppm Zn	19.21 d	19.49 e	13.99 f	14.50 e
Two weeks after full bloom+ 250ppm Zn	20.74 b-d	21.24 cd	15.14 c-e	15.67 cd
Two weeks after full bloom+ 500ppm Zn	22.42 ab	22.74 ab	15.97 a-c	16.71 a-c
Effect of interaction between application dates and Boron				
Full bloom + 0ppm B	19.18 c	19.59 b	14.19 b	14.62 d
Full bloom +250ppm B	23.22 a	23.56 a	16.71 a	17.42 a
Full bloom + 500 ppm B	22.14 ab	22.67 a	15.91 a	16.72 a-c
One week after full bloom+ 0ppm B	19.08 c	19.38 b	14.08 b	14.44 d
One week after full bloom+250ppm B	22.37 ab	23.40 a	16.24 a	17.24 ab
One week after full bloom+500ppm B	21.83 b	22.30 a	15.74 a	16.23 bc
Two weeks after full bloom+ 0ppm B	18.69 c	18.62 b	13.54 b	13.96 d
Two weeks after full bloom+ 250ppm B	22.24 ab	22.82 a	16.06 a	16.80 a-c
Two weeks after full bloom+ 500ppm B	21.44 b	22.03 a	15.50 a	16.12 c
Effect of interaction between zinc and Boron				
0 ppm Zn + 0 ppm B	18.22 g	18.24 g	13.23 f	13.68 g
0 ppm Zn +25 0 ppm B	20.60 de	21.49 ce	15.27 ce	15.78 ce
0 ppm Zn + 500 ppm B	20.10 ef	20.71 df	14.79 de	15.32 df
250 ppm Zn + 0 ppm B	19.18 fg	19.29 fg	14.21 ef	14.43 fg
250 ppm Zn + 250 ppm B	22.58 bc	23.21 bc	16.09 bc	16.80 bc
250 ppm Zn + 5000 ppm B	21.54 cd	22.36 bd	15.59 bd	16.24 cd
500 ppm Zn + 0 ppm B	19.54 ef	20.06 ef	14.37 df	14.91 ef
500 ppm Zn + 250 ppm B	24.66 a	25.08 a	17.66 a	18.89 a
500 ppm Zn + 500 ppm B	23.78 ab	23.93 ab	16.78 ab	17.51 b

Effect of application dates, zinc and Boron

Application dates	Zn (PPM)	B (PPM)	Cluster length (cm) 2017	Cluster length (cm) 2018	Cluster width (cm) 2017	Cluster width (cm) 2018
Full bloom	0	0	18.73 g-i	18.90 fg	13.83 h-j	14.23 i-k
Full bloom	0	250	20.80 d-g	21.77 b-f	15.37 c-i	15.97 d-i
Full bloom	0	500	20.30 d-h	21.20 c-f	15.07 c-i	15.50 e-j
Full bloom	250	0	19.17 f-i	19.47 fg	14.30 f-j	14.63 h-j
Full bloom	250	250	23.30 bc	23.43 a-d	16.40 a-f	16.90 c-f
Full bloom	250	500	22.10 b-d	22.63 a-e	15.73 b-h	16.63 c-g
Full bloom	500	0	19.63 e-i	20.40 ef	14.43 e-i	15.00 g-j
Full bloom	500	250	25.57 a	25.47 a	18.37 a	19.40 a
Full bloom	500	500	24.03 ab	24.17 a-c	16.93 a-c	18.03 a-c
One week after full bloom	0	0	18.50 hi	18.93 fg	13.60 ij	14.00 jk
One week after full bloom	0	250	20.57 d-h	21.50 b-f	15.23 c-i	15.87 d-i
One week after full bloom	0	500	20.23 d-h	20.57 d-f	14.80 d-i	15.27 f-j
One week after full bloom	250	0	19.23 f-i	19.33 fg	14.27 g-j	14.33 h-k
One week after full bloom	250	250	22.37 b-d	23.43 a-d	16.00 b-g	16.83 c-f
One week after full bloom	250	500	21.50 c-e	22.53	15.53 b-i	16.10 d-h
One week after full bloom	500	0	19.50 e-i	19.87 e-g	14.37 f-j	15.00 g-j
One week after full bloom	500	250	24.17 ab	25.27 a	17.50 ab	19.03 ab
One week after full bloom	500	500	23.77 ab	23.80 a-c	16.90 a-d	17.33 b-d
Two weeks after full bloom	0	0	17.43 i	16.90 g	12.27 j	12.80 k
Two weeks after full bloom	0	250	20.43 d-h	21.20 c-f	15.20 c-i	15.50 e-j
Two weeks after full bloom	0	500	19.77 e-h	20.37 ef	14.50 e-i	15.20 f-j
Two weeks after full bloom	250	0	19.13 f-i	19.07 fg	14.07 g-j	14.33 h-k
Two weeks after full bloom	250	250	22.07 b-d	22.77 a-e	15.87 b-h	16.67 c-g
Two weeks after full bloom	250	500	21.03 d-f	21.90 b-f	15.50 b-i	16.00 d-i
Two weeks after full bloom	500	0	19.50 e-i	19.90 e-g	14.30 f-j	14.73 h-j
Two weeks after full bloom	500	250	24.23 ab	24.50 ab	17.10 a-c	18.23 a-c
Two weeks after full bloom	500	500	23.53 a-c	23.83 a-c	16.50 a-e	17.17 c-e

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

Furthermore, foliar spray with Zn at 500 ppm plus B at 250 ppm exerted the highest positive effect on cluster width as compared with other combinations in both seasons.

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

3.1.5. Number of berries per cluster

Fig. (5) and table (3) indicates that three application dates failed to induce any positive effect on number of berries per cluster in both seasons. Zinc foliar spray at 500 ppm exerted high positive effect on number of berries per cluster than other treatments in both seasons. Boron foliar spray at 250 ppm gave the highest values of number of berries per cluster in both seasons.

The interaction between application dates and foliar spray with zinc reveals that 500 ppm zinc foliar spray at full bloom and 500 ppm zinc foliar spray at one week after full bloom gave similar effect and high significant effect on number of berries per cluster 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 gave the highest positive effect on number of berries per cluster as compared with other combinations in both seasons. Combination of foliar spray with Zn at 500 ppm plus foliar spray with B at 250 ppm exerted high significant effect on number of berries per cluster as compared with other combinations in both seasons.

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 enhancing number of berries per cluster as compared with other combinations in both seasons.

3.1.6. Cluster compactness coefficient

Fig. (6) and table (3) shows that three application dates failed to induce any positive effect on cluster compactness coefficient in both seasons. Zinc foliar spray at 250 or 500 ppm in the first season and 250 ppm in the second season induced the highest reduction effect on cluster compactness coefficient than other treatments. Boron foliar spray at 500 ppm show significant reduction effect on cluster compactness coefficient in both seasons while spraying at 250 ppm showed the same effect in the second season only.

The interaction between application dates and foliar spray with zinc reveals that 250 ppm zinc foliar spray at full bloom in both seasons, 500 ppm zinc foliar spray at two weeks after full bloom in the first season, 500 ppm at full bloom and 250 ppm zinc foliar spray at one week after full bloom in the second season induced the same effect and the highest reduction effect on cluster compactness coefficient than other treatments. In addition, the interaction between application dates and foliar spray with boron failed to show any significant effect on cluster compactness coefficient in first season but in the second season 500 ppm B foliar spray at full bloom induced the highest reduction effect on cluster compactness coefficient. Combination of foliar spray with Zn at 500 ppm plus foliar spray with B at 500 ppm reduced cluster compactness coefficient as compared with other combinations and control in both seasons.

Finally, the combination among the three studied factors indicates that the combination of 500 ppm Zn + 500 ppm B foliar spray at full bloom or two weeks after full bloom surpassed the other combinations in induced high reduction effect on cluster compactness coefficient in first season but in the second season 250 ppm Zn + 2500 ppm B foliar spray at one week after full bloom induced high reduction effect as compared with other combinations in this respect.

3.1.7. Weight of 100 berries

It is obvious from Fig. (7) and table (4) that three application dates failed to induce any positive effect on weight of 100 berries in both seasons. Zinc foliar spray at 250 and 500 ppm exerted the highest positive effect on weight of 100 berries in both seasons. Furthermore, 250 ppm boron foliar spray in both season and 500 ppm boron foliar spray in the second season produced similar effect and the highest values of weight of 100 berries as compared with those untreated vines.

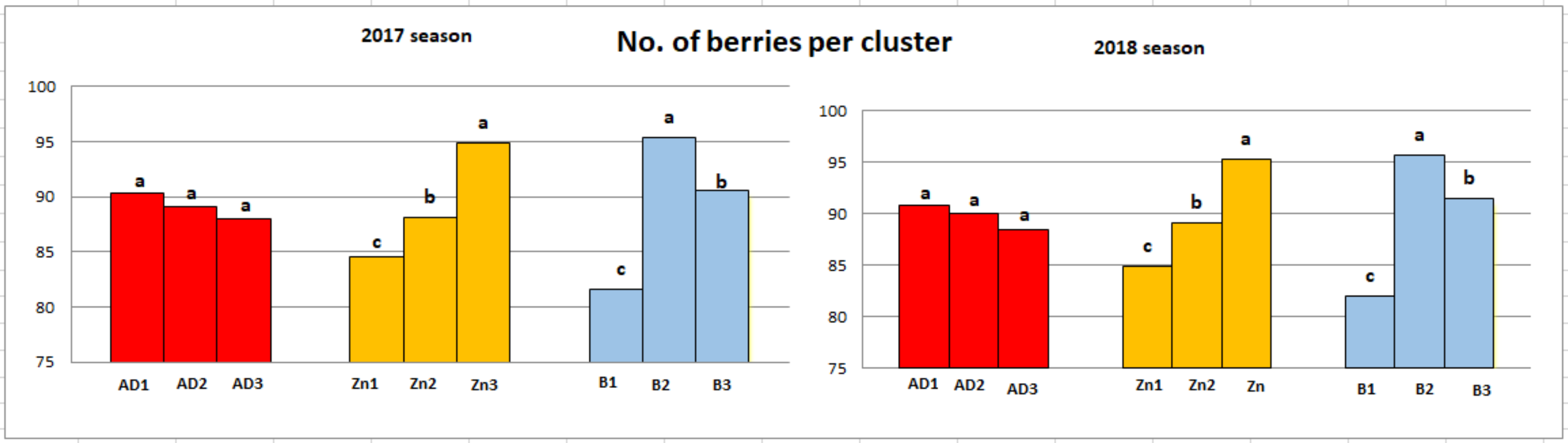

Fig. 5: Effect of application dates (AD), foliar spray of Zn and B on number of berries per cluster of "Early Sweet" grapes during 2017 and 2018 seasons.

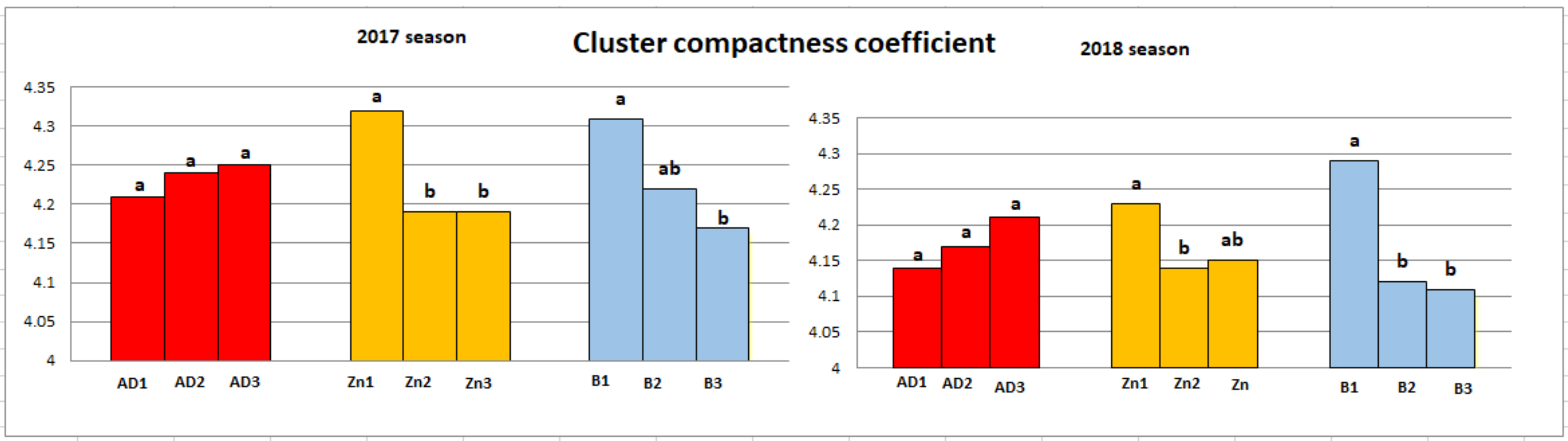

Fig. 6: Effect of application dates (AD), foliar spray of Zn and B on cluster compactness coefficient of "Early Sweet" grapes during 2017 and 2018 seasons.

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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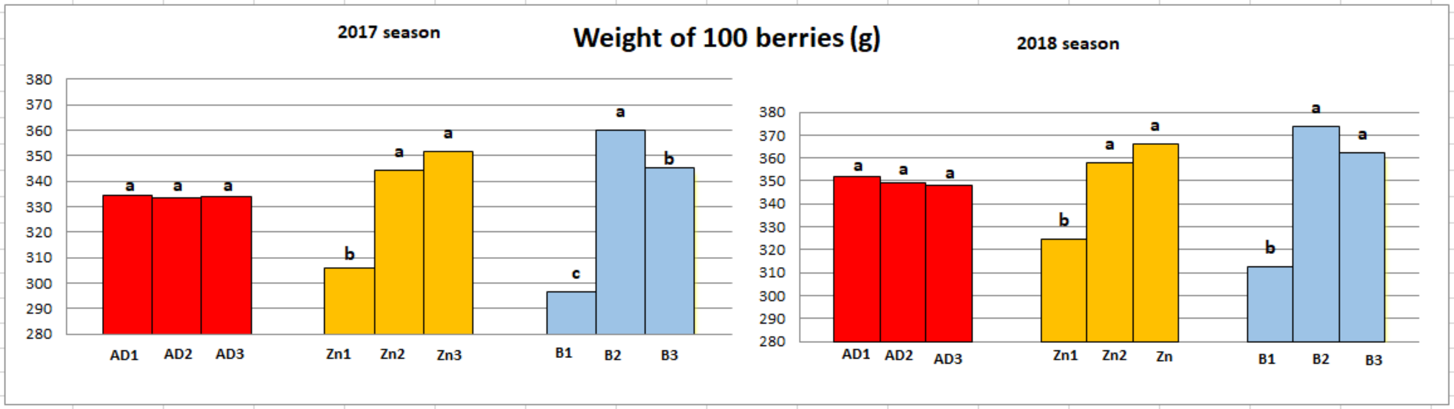

Fig. 7: Effect of application dates (AD), foliar spray of Zn and B on weight of 100 berries(g) of "Early Sweet" grapes during 2017 and 2018 seasons.

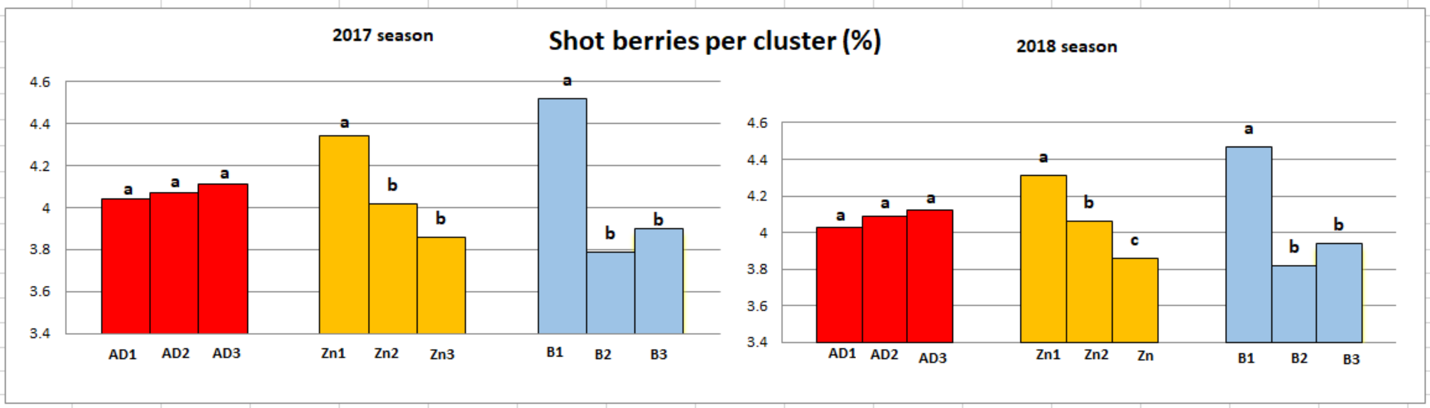

Fig. 8: Effect of application dates (AD), foliar spray of Zn and B on shot berries per cluster (%) of "Early Sweet" grapes during 2017 and 2018 seasons.

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 3: Effect of interactions among application dates, foliar spray of Zn and B on number of berries per cluster and cluster compactness coefficient of "Early Sweet" grapes during 2017 and 2018 seasons.

Treatments	No. of berries /cluster		Cluster compactness coefficient	
	2017	2018	2017	2018
Effect of interaction between application dates and zinc				
Full bloom + 0 ppm Zn	85.11 cd	86.00 cd	4.27 a-c	4.18 ab
Full bloom +250 ppm Zn	88.89 bc	89.78 bc	4.15 c	4.13 b
Full bloom + 500 ppm Zn	97.11 a	96.44 a	4.22 bc	4.13 b
One week after full bloom+ 0 ppm Zn	84.89 cd	85.33 cd	4.30 ab	4.23 ab
One week after full bloom+250 ppm Zn	88.00 cd	88.67 bc	4.20 bc	4.09 b
One week after full bloom+500 ppm Zn	94.44 a	95.78 a	4.21 bc	4.18 ab
Two weeks after full bloom+ 0 ppm Zn	83.78 d	83.11 d	4.37 a	4.29 a
Two weeks after full bloom+ 250 ppm Zn	87.33 cd	88.67 bc	4.21 bc	4.19 ab
Two weeks after full bloom+ 500 ppm Zn	92.89 ab	93.56 ab	4.15 c	4.14 ab
Effect of interaction between application dates and Boron				
Full bloom + 0ppm B	82.22 d	83.33 d	4.29 a	4.26 ab
Full bloom +250ppm B	97.56 a	96.89 a	4.20 a	4.11 bc
Full bloom + 500 ppm B	91.33 bc	92.00 a-c	4.14 a	4.06 c
One week after full bloom+ 0ppm B	81.78 d	82.44 d	4.30 a	4.28 ab
One week after full bloom+250ppm B	94.89 ab	96.00 ab	4.24 a	4.10 bc
One week after full bloom+500ppm B	90.67 bc	91.33 bc	4.17 a	4.11 bc
Two weeks after full bloom+ 0ppm B	80.67 d	80.22 d	4.32 a	4.33 a
Two weeks after full bloom+ 250ppm B	93.78 a-c	94.22 a-c	4.22 a	4.15 a-c
Two weeks after full bloom+ 500ppm B	89.56 c	90.89 c	4.20 a	4.14 a-c
Effect of interaction between zinc and Boron				
0 ppm Zn + 0 ppm B	80.00 f	78.67 g	4.40 a	4.34 a
0 ppm Zn +25 0 ppm B	87.56 d	88.89 c-e	4.25 ab	4.15 a-c
0 ppm Zn + 500 ppm B	86.22 de	86.89 d-f	4.30 ab	4.20 a-c
250 ppm Zn + 0 ppm B	81.78 ef	82.44 fg	4.27 ab	4.28 a
250 ppm Zn + 250 ppm B	93.11 bc	93.78 bc	4.13 bc	4.04 c
250 ppm Zn + 5000 ppm B	89.33 cd	90.89 cd	4.16 bc	4.08 bc
500 ppm Zn + 0 ppm B	82.89 ef	84.89 ef	4.24 ab	4.25 ab
500 ppm Zn + 250 ppm B	105.56 a	104.44 a	4.28 ab	4.17 a-c
500 ppm Zn + 500 ppm B	96.00 b	96.44 b	4.05 c	4.04 c

Effect of application dates, zinc and Boron

Application dates	Zn (PPM)	B (PPM)	No. of berries /cluster		Cluster compactness coefficient	
			2017	2018	2017	2018
Full bloom	0	0	80.67 kl	81.33 j-l	4.31 a-c	4.30 ab
Full bloom	0	250	88.00 e-k	89.33 d-j	4.24 a-c	4.10 ab
Full bloom	0	500	86.67 f-l	87.33 f-k	4.27 a-c	4.12 ab
Full bloom	250	0	82.00 i-l	83.33 h-l	4.29 a-c	4.30 ab
Full bloom	250	250	94.67 c-f	94.67 c-f	4.07 bc	4.04 b
Full bloom	250	500	90.00 d-i	91.33 d-h	4.08 bc	4.04 b
Full bloom	500	0	84.00 h-l	85.33 g-k	4.28 a-c	4.18 ab
Full bloom	500	250	110.00 a	106.67 a	4.30 a-c	4.19 ab
Full bloom	500	500	97.33 b-d	97.33 b-d	4.07 bc	4.02 b
One week after full bloom	0	0	80.67 kl	80.00 kl	4.37 ab	4.31 ab
One week after full bloom	0	250	87.33 f-k	89.33 d-j	4.25 a-c	4.15 ab
One week after full bloom	0	500	86.67 f-l	86.67 f-k	4.28 a-c	4.22 ab
One week after full bloom	250	0	82.00 i-l	82.00 i-l	4.27 a-c	4.24 ab
One week after full bloom	250	250	92.67 d-g	93.33 c-g	4.14 bc	3.98 b
One week after full bloom	250	500	89.33 d-j	90.67 d-i	4.18 bc	4.05 b
One week after full bloom	500	0	82.67 i-l	85.33 g-k	4.25 a-c	4.30 ab
One week after full bloom	500	250	104.67 ab	105.33 ab	4.34 a-c	4.17 ab
One week after full bloom	500	500	96.00 c-e	96.67 b-e	4.04 c	4.08 b
Two weeks after full bloom	0	0	78.67 l	74.67 l	4.51 a	4.42 a
Two weeks after full bloom	0	250	87.33 f-k	88.00 e-k	4.27 a-c	4.19 ab
Two weeks after full bloom	0	500	85.33 g-l	86.67 f-k	4.34 a-c	4.25 ab
Two weeks after full bloom	250	0	81.33 j-l	82.00 i-l	4.25 a-c	4.30 ab
Two weeks after full bloom	250	250	92.00 d-h	93.33 c-g	4.17 bc	4.10 ab
Two weeks after full bloom	250	500	88.67 e-k	90.67 d-i	4.21 a-c	4.16 ab
Two weeks after full bloom	500	0	82.00 i-l	84.00 h-k	4.21 a-c	4.25 ab
Two weeks after full bloom	500	250	102.00 a-c	101.33 a-c	4.21 a-c	4.16 ab
Two weeks after full bloom	500	500	94.67 c-f	95.33 c-f	4.04 c	4.01b

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

The combination between application dates and foliar spray with zinc reveals that all tested combinations increased weight of 100 berries as compared with control in the first season. And 500 ppm zinc foliar spray at full bloom and 500 ppm zinc foliar spray at two week after full bloom in the second season gave similar effect and the highest positive effect on weight of 100 berries. In addition, the combination between application dates and foliar spray with boron reveals that all tested combinations increased weight of 100 berries in both seasons. Combination of foliar spray with Zn at 250 ppm plus foliar spray with B at 250 ppm and combination of foliar spray with Zn at 500 ppm plus foliar spray with B at 500 ppm exerted the highest positive effect on weight of 100 berries as compared with other combinations in both seasons.

The combination among the three studied factors indicates that the combination of 500 ppm Zn plus 500 ppm B foliar spray at full bloom in both seasons, combination of 500 ppm Zn plus 500 ppm B foliar spray at one week after full bloom in the first season, combination of 250 ppm Zn plus 250 ppm B foliar spray at two week after full bloom in the first season and combination of 500 ppm Zn plus 500 ppm B foliar spray at two week after full bloom in the first season surpassed the other combinations in enhancing weight of 100 berries.

3.1.8. Shot berries per cluster percentage

It is obvious from Fig. (8) and table (4) that three application dates had no significant effect on shot berries per cluster percentage in both seasons. Moreover, 250 and 500 ppm zinc foliar spray induced similar effect and high reduction effect on shot berries per cluster percentage as compared with control in both seasons. Furthermore, 250 and 500 ppm boron foliar spray induced similar effect and high reduction effect on shot berries percentage per cluster percentage as compared with control in both seasons.

On the other hand, the combination between application dates and foliar spray with zinc reveals that 500 ppm zinc foliar spray at full bloom induced the highest reduction effect on shot berries per cluster percentage in both seasons. In addition, the combination between application dates and foliar spray with boron reveals that 250 ppm boron foliar spray at full bloom induced the highest reduction effect on shot berries per cluster percentage in both seasons. Furthermore, foliar spray with Zn at 500 ppm plus B at 250 ppm exerted the highest reduction effect on shot berries per cluster percentage as compared with other combinations in both seasons.

Finally, the combination 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 induced high reduction effect on shot berries per cluster percentage as compared with other combinations in both seasons.

3.1.9. berry length (cm)

It is clear from Fig. (9) and table (5) that in first seasons, application date (full bloom) foliar spray vines gave the highest values of berry length. But three application dates failed to induce any significant effect on berry length in second season. Moreover, 500 ppm zinc foliar spray produced the highest value of berry length than other treatments in both seasons. Furthermore, 250 ppm boron foliar spray increased berry length as compared with other treatments in both seasons.

On the other hand, the interaction between application dates and foliar spray with zinc reveals that 500 ppm zinc foliar spray at full bloom in both seasons, 500 ppm zinc foliar spray at one week after full bloom in second season exerted the similar effect and the highest positive effect on berry length 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 berry length values as compared with other combinations in both seasons. Furthermore, foliar spray with zinc at 500 ppm + boron at 250 ppm gave the highest positive effect on berry length values as compared with other combinations in both seasons.

Finally, the combination 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 berry length as compared with other combinations in both seasons.

Table 4: Effect of interactions among application dates, foliar spray of Zn and B on weight of 100 berries and shot berries per cluster percentage of "Early Sweet" grapes during 2017 and 2018 seasons.

Treatments	Weight of 100 berries		Shot berries per cluster (%)	
	2017	2018	2017	2018
Effect of interaction between application dates and zinc				
Full bloom + 0ppm Zn	309.3 b	330.7 b-d	4.32 a	4.26 a-c
Full bloom +250ppm Zn	346.6 a	359.2 ab	3.97 b	4.03 c-e
Full bloom + 500 ppm Zn	347.0 a	365.7 a	3.82 b	3.79 e
One week after full bloom+ 0ppm Zn	302.5 b	324.2 cd	4.33 a	4.32 ab
One week after full bloom+250ppm Zn	344.7 a	358.5 a-c	4.02 ab	4.07 cd
One week after full bloom+500ppm Zn	353.3 a	364.9 ab	3.87 b	3.87 de
Two weeks after full bloom+ 0ppm Zn	305.8 b	319.3 d	4.36 a	4.35 a
Two weeks after full bloom+ 250ppm Zn	341.4 a	356.8 a-c	4.06 ab	4.09 b-d
Two weeks after full bloom+ 500ppm Zn	354.5 a	368.1 a	3.90 b	3.93 de
Effect of interaction between application dates and Boron				
Full bloom + 0ppm B	297.0 b	311.9 b	4.48 a	4.41 a
Full bloom +250ppm B	358.2 a	373.8 a	3.76 b	3.74 c
Full bloom + 500 ppm B	347.7 a	369.9 a	3.87 b	3.93 bc
One week after full bloom+ 0ppm B	297.0 b	313.2 b	4.51 a	4.48 a
One week after full bloom+250ppm B	360.5 a	373.6 a	3.80 b	3.86 bc
One week after full bloom+500ppm B	343.0 a	360.7 a	3.91 b	3.93 bc
Two weeks after full bloom+ 0ppm B	295.4 b	313.1 b	4.58 a	4.52 a
Two weeks after full bloom+ 250ppm B	360.9 a	374.3 a	3.83 b	3.88 bc
Two weeks after full bloom+ 500ppm B	345.4 a	356.8 a	3.92 b	3.97 b
Effect of interaction between zinc and Boron				
0 ppm Zn + 0 ppm B	281.3 e	300.4 d	4.98a	4.77 a
0 ppm Zn +25 0 ppm B	331.1 c	347.4 bc	3.98 c-e	4.04 de
0 ppm Zn + 500 ppm B	305.3 d	326.3 cd	4.06 b-d	4.13 cd
250 ppm Zn + 0 ppm B	301.9 de	319.3 cd	4.36 b	4.38 b
250 ppm Zn + 250 ppm B	384.4 a	390.4 a	3.77 de	3.86 ef
250 ppm Zn + 5000 ppm B	346.4 bc	364.7 ab	3.92 c-e	3.95 d-f
500 ppm Zn + 0 ppm B	306.2 d	318.4 cd	4.23 bc	4.26 bc
500 ppm Zn + 250 ppm B	364.2 ab	383.8 ab	3.64 e	3.57 g
500 ppm Zn + 500 ppm B	384.4 a	396.4 a	3.72 de	3.75 fg

Effect of application dates, zinc and Boron

Application dates	Zn (PPM)	B (PPM)	Weight of 100 berries		Shot berries per cluster (%)	
			2017	2018	2017	2018
Full bloom	0	0	281.9 g	299.8 e	4.97 ab	4.66 a-c
Full bloom	0	250	341.2 b-e	350.1 a-e	3.97 c-g	4.00 e-j
Full bloom	0	500	305.0 d-g	342.3 a-e	4.03 c-g	4.12 d-h
Full bloom	250	0	304.9 d-g	318.0 c-e	4.30 c-e	4.33 c-e
Full bloom	250	250	380.5 ab	391.1 ab	3.72 e-g	3.82 h-j
Full bloom	250	500	354.3 a-c	368.5 a-c	3.88 c-g	3.94 f-j
Full bloom	500	0	304.2 d-g	318.1 c-e	4.18 c-g	4.24 d-g
Full bloom	500	250	353.1 a-c	380.0 ab	3.57 g	3.39 k
Full bloom	500	500	383.8 a	399.0 a	3.70 e-g	3.73 i-k
One week after full bloom	0	0	278.5 g	302.7 de	4.96 ab	4.79 ab
One week after full bloom	0	250	326.6 c-f	351.3 a-e	3.76 d-g	4.06 d-i
One week after full bloom	0	500	302.5 e-g	318.4 c-e	4.06 c-g	4.12 d-h
One week after full bloom	250	0	305.6 d-g	319.7 c-e	4.36 b-d	4.40 cd
One week after full bloom	250	250	385.5 a	389.6 ab	3.76 d-g	3.88 g-j
One week after full bloom	250	500	342.9 b-d	366.0 a-c	3.94 c-g	3.94 f-j
One week after full bloom	500	0	307.0 d-g	317.1 c-e	4.21 c-f	4.24 d-g
One week after full bloom	500	250	369.3 ab	379.9 ab	3.67 fg	3.64 jk
One week after full bloom	500	500	383.6 a	397.7 ab	3.73 e-g	3.73 i-k
Two weeks after full bloom	0	0	283.6 g	298.8 e	5.00 a	4.85 a
Two weeks after full bloom	0	250	325.4 c-f	340.8 b-e	4.00 c-g	4.06 d-i
Two weeks after full bloom	0	500	308.4 d-g	318.3 c-e	4.09 c-g	4.15 d-h
Two weeks after full bloom	250	0	295.1 fg	320.3 c-e	4.42 a-c	4.42 b-d
Two weeks after full bloom	250	250	387.2 a	390.4 ab	3.82 c-g	3.88 g-j
Two weeks after full bloom	250	500	341.8 b-e	359.6 a-d	3.94 c-g	3.97 e-j
Two weeks after full bloom	500	0	307.4 d-g	320.1 c-e	4.30 c-e	4.30 c-f
Two weeks after full bloom	500	250	370.2 ab	391.6 ab	3.67 fg	3.70 i-k
Two weeks after full bloom	500	500	385.8 a	392.6 ab	3.73 e-g	3.79 h-j

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

3.1.10. berry width (cm)

It is obvious from Fig. (10) and table (5) that in first season, three application dates failed to induce any significant effect on berry width values. But in second season, application date (full bloom) foliar spray vines gave the highest berry width values in this respect. Moreover, 500 ppm zinc foliar spray produced the highest value of berry width than other treatments in both seasons. Furthermore, 250 and 500 ppm boron foliar spray increased berry width as compared with control in both seasons.

On the other hand, the combination between application dates and foliar spray with zinc reveals that 500 ppm zinc foliar spray at full bloom in both seasons, 500 ppm zinc foliar spray at one week after full bloom in second season exerted the similar effect and the highest positive effect on berry width values in this respect. In addition, the combination between application dates and foliar spray with boron reveals that the combination of 250 ppm or 500 ppm boron foliar spray at any of application dates induced positive effect on berry width values as compared with control in both seasons in this respect. Furthermore, foliar spray with zinc at 500 ppm + boron at 250 ppm gave the highest positive effect on berry width values as compared with other combinations in both seasons.

Finally, the combination among the three studied factors indicates that the combination of 500 ppm Zn + 250 ppm B foliar spray at full bloom in both seasons and combination of 500 ppm Zn + 250 ppm B foliar spray at one week after full bloom in the second season gave similar effect and surpassed the other combinations in enhancing berry width values as compared with other combinations.

3.2. Fruit chemical properties

3.2.1. T.S.S. (%)

Fig. (11) and table (6) demonstrates that concerning the application dates there no significant difference effect on TSS in both seasons. Zinc foliar spray at 500 ppm induced the highest positive effect on TSS values in both seasons. Boron foliar spray at 250 ppm in both seasons and boron foliar spray at 500 ppm in the second season induced similar effect and the highest values of TSS than other treatments.

The interaction between application dates and foliar spray with zinc reveals that 500 ppm zinc foliar spray at full bloom in both seasons and 500 ppm zinc foliar spray at one week after full bloom in the first season gave similar effect and the highest positive effect on TSS values. In addition, the interaction between application dates and foliar spray with boron reveals that the combination of 250 ppm boron foliar spray at full bloom induced high positive effect on TSS values as compared with other combinations in first season; all treatments have positive effect on TSS values compared with control in second season. Combination of foliar spray with Zn at 500 ppm plus foliar spray with B at 250 ppm gave the highest positive effect on TSS values as compared with other combinations in both seasons.

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 enhancing TSS values as compared with other combinations in both seasons.

3.2.2. Acidity (%)

It is obvious from Fig. (12) and table (6) that in first season, application date (full bloom) reduced acidity values than other application dates (one week after full bloom and two week after full bloom). But three application dates of foliar spray had no significant effect on acidity in second season. Moreover, 500 ppm zinc foliar spray induced the highest reduction effect on acidity than other treatments in both seasons. Furthermore, 250 ppm boron foliar spray induced the highest reduction effect on acidity as compared with control in both seasons.

On the other hand, the combination between application dates and foliar spray with zinc reveals that 500 ppm zinc foliar spray at full bloom induced the highest reduction effect on acidity in both seasons. In addition, the combination between application dates and foliar spray with boron reveals that 250 ppm boron foliar spray at full bloom induced the highest reduction effect on acidity in both seasons. Furthermore, foliar spray with Zn at 500 ppm plus B at 250 ppm gave the highest reduction effect on acidity in both seasons.

The combination among the three studied factors indicates that the interactions of 500 ppm Zn + 250 ppm B foliar spray at full bloom surpassed the other combinations in induced reduction effect on acidity in both seasons.

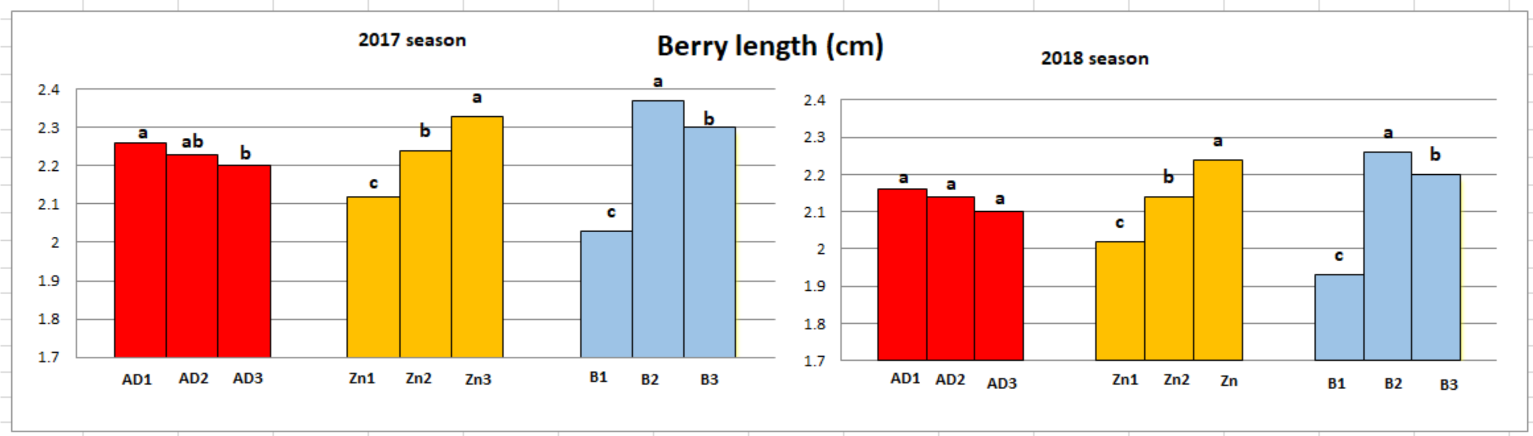

Fig. 9: Effect of application dates (AD), foliar spray of Zn and B on berry length (cm)of "Early Sweet" grapes during 2017 and 2018 seasons

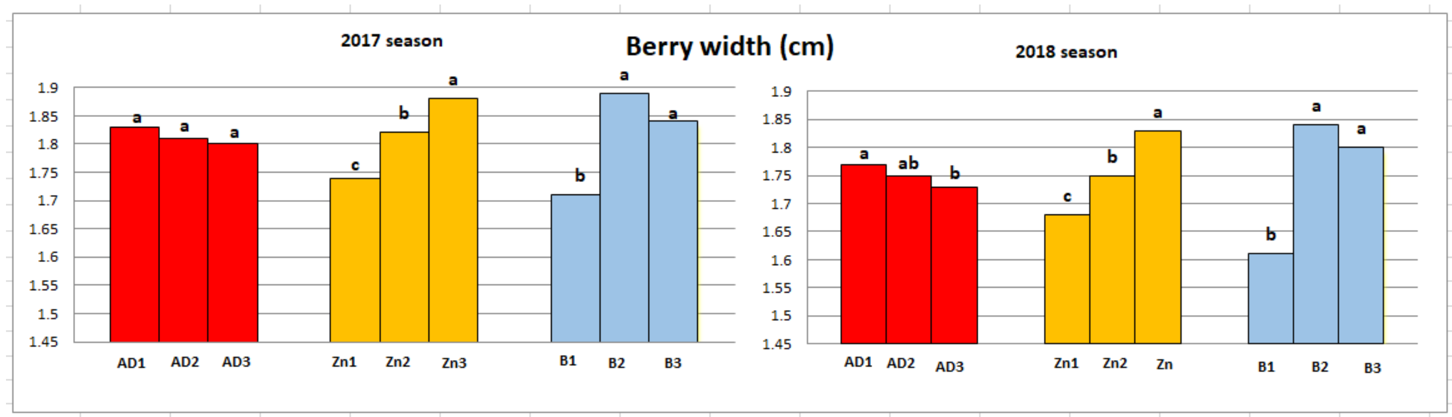

Fig. 10: Effect of application dates (AD), foliar spray of Zn and B on berry width (cm) of "Early Sweet" grapes during 2017 and 2018 seasons.

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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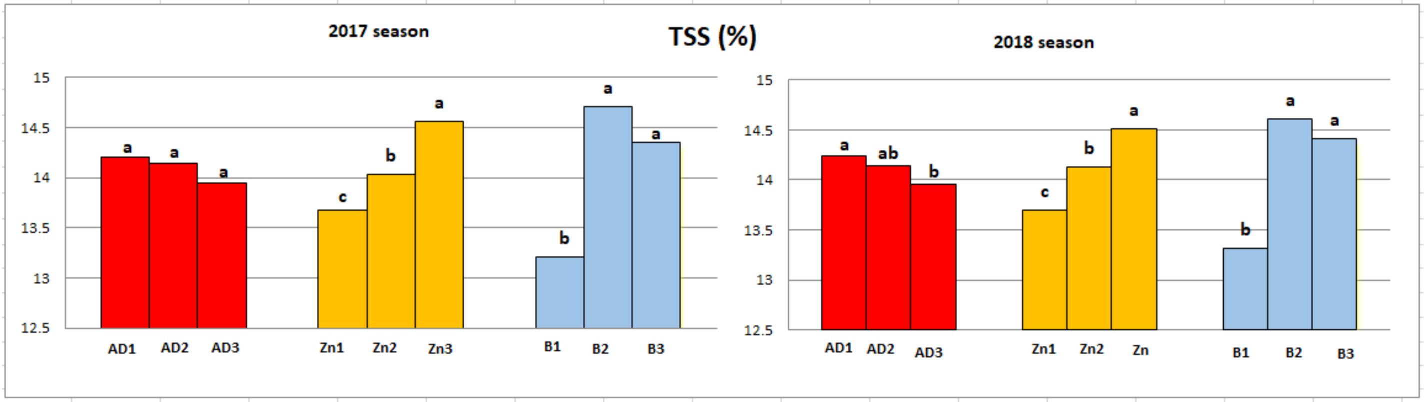

Fig. 11: Effect of application dates (AD), foliar spray of Zn and B TSS (%)of "Early Sweet" grapes during 2017 and 2018 seasons.

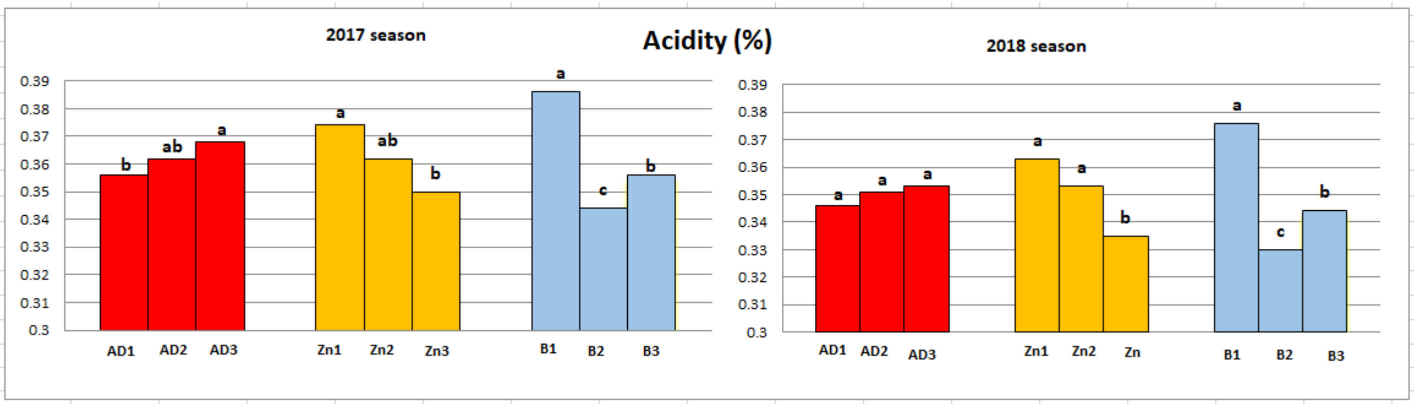

Fig. 12: Effect of application dates (AD), foliar spray of Zn and B Acidity (%) of "Early Sweet" grapes during 2017 and 2018 seasons.

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 5: Effect of interactions among application dates, foliar spray of Zn and B on berry length (cm) and berry width (cm) of "Early Sweet" grapes during 2017 and 2018 seasons.

Treatments	Berry length (cm)		Berry width (cm)	
	2017	2018	2017	2018
Effect of interaction between application dates and zinc				
Full bloom + 0ppm Zn	2.16 c-e	2.06 de	1.78 c-e	1.70 bc
Full bloom +250ppm Zn	2.26 bc	2.16 bc	1.82 a-c	1.77 a-c
Full bloom + 500 ppm Zn	2.38 a	2.27 a	1.90 a	1.83 a
One week after full bloom+ 0ppm Zn	2.12 de	2.02 e	1.73 de	1.68 c
One week after full bloom+250ppm Zn	2.26 bc	2.14 bc	1.82 a-c	1.74 a-c
One week after full bloom+500ppm Zn	2.32 ab	2.24 a	1.88 ab	1.83 a
Two weeks after full bloom+ 0ppm Zn	2.09 e	1.99 e	1.72 e	1.66 c
Two weeks after full bloom+ 250ppm Zn	2.22 b-d	2.11 cd	1.81 b-d	1.73 a-c
Two weeks after full bloom+ 500ppm Zn	2.30 ab	2.20 ab	1.87 ab	1.81 ab
Effect of interaction between application dates and Boron				
Full bloom + 0ppm B	2.06 c	1.97 c	1.73 b	1.63 b
Full bloom +250ppm B	2.41 a	2.29 a	1.91 a	1.86 a
Full bloom + 500 ppm B	2.32 ab	2.22 ab	1.86 a	1.81 a
One week after full bloom+ 0ppm B	2.03 c	1.93 c	1.70 b	1.61 b
One week after full bloom+250ppm B	2.36 ab	2.27 ab	1.89 a	1.84 a
One week after full bloom+500ppm B	2.31 ab	2.21 ab	1.84 a	1.80 a
Two weeks after full bloom+ 0ppm B	2.00 c	1.90 c	1.69 b	1.60 b
Two weeks after full bloom+ 250ppm B	2.34 ab	2.23 ab	1.88 a	1.82 a
Two weeks after full bloom+ 500ppm B	2.27 b	2.17 b	1.83 a	1.78 a
Effect of interaction between zinc and Boron				
0 ppm Zn + 0 ppm B	1.94 g	1.84 g	1.64 f	1.54 g
0 ppm Zn +25 0 ppm B	2.24 cd	2.14 cd	1.81 c-e	1.77 cd
0 ppm Zn + 500 ppm B	2.18 de	2.08 de	1.78 de	1.72 de
250 ppm Zn + 0 ppm B	2.03 fg	1.94 fg	1.73 e	1.63 f
250 ppm Zn + 250 ppm B	2.39 ab	2.26 b	1.89 bc	1.83 bc
250 ppm Zn + 5000 ppm B	2.31 bc	2.21 bc	1.83 cd	1.78 cd
500 ppm Zn + 0 ppm B	2.11 ef	2.01 ef	1.74 e	1.67 ef
500 ppm Zn + 250 ppm B	2.48 a	2.39 a	1.98 a	1.92 a
500 ppm Zn + 500 ppm B	2.41 ab	2.31 ab	1.92 ab	1.89 ab

Effect of application dates, zinc and Boron

Application dates	Zn (PPM)	B (PPM)	Berry length (cm) 2017	Berry length (cm) 2018	Berry width (cm) 2017	Berry width (cm) 2018
Full bloom	0	0	2.00 hi	1.90 ij	1.70 f-h	1.60 g-i
Full bloom	0	250	2.27 b-e	2.17 c-f	1.83 b-f	1.77 b-f
Full bloom	0	500	2.20 d-g	2.10 e-h	1.80 c-f	1.73 c-g
Full bloom	250	0	2.03 g-i	1.97 g-j	1.73 e-h	1.63 f-i
Full bloom	250	250	2.40 a-c	2.27 a-e	1.90 a-d	1.87 a-c
Full bloom	250	500	2.33 b-d	2.23 b-e	1.83 b-f	1.80 a-e
Full bloom	500	0	2.13 e-h	2.03 f-i	1.77 d-g	1.67 e-h
Full bloom	500	250	2.57 a	2.43 a	2.00 a	1.93 a
Full bloom	500	500	2.43 ab	2.33 a-c	1.93 a-c	1.90 ab
One week after full bloom	0	0	1.93 i	1.83 j	1.63 gh	1.53 hi
One week after full bloom	0	250	2.23 c-f	2.13 d-g	1.90 a-d	1.77 b-f
One week after full bloom	0	500	2.20 d-g	2.10 e-h	1.77 d-g	1.73 c-g
One week after full bloom	250	0	2.03 g-i	1.93 h-j	1.73 e-h	1.63 f-i
One week after full bloom	250	250	2.40 a-c	2.27 a-e	1.90 a-d	1.83 a-d
One week after full bloom	250	500	2.33 b-d	2.23 b-e	1.83 b-f	1.77 b-f
One week after full bloom	500	0	2.13 e-h	2.03 f-i	1.73 e-h	1.67 e-h
One week after full bloom	500	250	2.43 ab	2.40 ab	1.97 ab	1.93 a
One week after full bloom	500	500	2.40 a-c	2.30 a-d	1.93 a-c	1.90 ab
Two weeks after full bloom	0	0	1.90 i	1.80 j	1.60 h	1.50 i
Two weeks after full bloom	0	250	2.23 c-f	2.13 d-g	1.80 c-f	1.77 b-f
Two weeks after full bloom	0	500	2.13 e-h	2.03 f-i	1.77 d-g	1.70 d-g
Two weeks after full bloom	250	0	2.03 g-i	1.93 h-j	1.73 e-h	1.63 f-i
Two weeks after full bloom	250	250	2.37 b-d	2.23 b-e	1.87 a-e	1.80 a-e
Two weeks after full bloom	250	500	2.27 b-e	2.17 c-f	1.83 b-f	1.77 b-f
Two weeks after full bloom	500	0	2.07 f-i	1.97 g-j	1.73 e-h	1.67 e-h
Two weeks after full bloom	500	250	2.43 ab	2.33 a-c	1.97 ab	1.90 ab
Two weeks after full bloom	500	500	2.40 a-c	2.30 a-d	1.90 a-d	1.87 a-c

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

Table 6: Effect of interactions among application dates, foliar spray of Zn and B on TSS (%) and Acidity (%) of "Early Sweet" grapes during 2017 and 2018 seasons.

Treatments	TSS (%)		Acidity (%)	
	2017	2018	2017	2018
Effect of interaction between application dates and zinc				
Full bloom + 0ppm Zn	13.75 cd	13.88 de	0.371 ab	0.360 ab
Full bloom +250ppm Zn	14.08 bc	14.22 a-d	0.358 a-c	0.349 a-c
Full bloom + 500 ppm Zn	14.76 a	14.63 a	0.340 c	0.329 d
One week after full bloom+ 0ppm Zn	13.75 cd	13.77 de	0.373 ab	0.364 a
One week after full bloom+250ppm Zn	14.06 bc	14.13 b-d	0.360 a-c	0.356 ab
One week after full bloom+500ppm Zn	14.60 a	14.53 ab	0.353 bc	0.333 cd
Two weeks after full bloom+ 0ppm Zn	13.54 d	13.46 e	0.378 a	0.364 a
Two weeks after full bloom+ 250ppm Zn	13.97 b-d	14.04 cd	0.369 ab	0.353 ab
Two weeks after full bloom+ 500ppm Zn	14.33 ab	14.36 a-c	0.358 a-c	0.342 b-d
Effect of interaction between application dates and Boron				
Full bloom + 0ppm B	13.32 c	13.50 b	0.380 a	0.371a
Full bloom +250ppm B	14.83 a	14.78 a	0.336 c	0.327 d
Full bloom + 500 ppm B	14.44 ab	14.45 a	0.353 b	0.340 b-d
One week after full bloom+ 0ppm B	13.25 c	13.47 b	0.387 a	0.378 a
One week after full bloom+250ppm B	14.80 ab	14.54 a	0.344 bc	0.331 cd
One week after full bloom+500ppm B	14.36 ab	14.42 a	0.356 b	0.344 bc
Two weeks after full bloom+ 0ppm B	13.07 c	13.00 b	0.391 a	0.380 a
Two weeks after full bloom+ 250ppm B	14.51 ab	14.53 a	0.353 b	0.331 cd
Two weeks after full bloom+ 500ppm B	14.26 b	14.35 a	0.360 b	0.349 b
Effect of interaction between zinc and Boron				
0 ppm Zn + 0 ppm B	12.96 f	12.74 f	0.393 a	0.384 a
0 ppm Zn +25 0 ppm B	14.11 cd	14.29 b-d	0.362 b-d	0.349 d
0 ppm Zn + 500 ppm B	13.97 de	14.08 cd	0.367 bc	0.356 cd
250 ppm Zn + 0 ppm B	13.25 f	13.36 e	0.387 a	0.378 ab
250 ppm Zn + 250 ppm B	14.54 bc	14.62 a-c	0.349 d	0.331 e
250 ppm Zn + 5000 ppm B	14.31 b-d	14.42 a-d	0.351 cd	0.349 d
500 ppm Zn + 0 ppm B	13.43 ef	13.86 de	0.378 ab	0.367 bc
500 ppm Zn + 250 ppm B	15.48 a	14.94 a	0.322 e	0.309 f
500 ppm Zn + 500 ppm B	14.78 b	14.72 ab	0.351 cd	0.329 e

Application dates	Zn (PPM)	B (PPM)	TSS (%) 2017	TSS (%) 2018	Acidity (%) 2017	Acidity (%) 2018
Effect of application dates, zinc and Boron						
Full bloom	0	0	13.07 jk	13.18 fg	0.387 a-c	0.380 ab
Full bloom	0	250	14.15 c-h	14.31 b-d	0.360 c-f	0.347 c-g
Full bloom	0	500	14.04 d-i	14.15 b-f	0.367 b-f	0.353 b-f
Full bloom	250	0	13.28 h-k	13.50 d-g	0.380 a-d	0.373 a-c
Full bloom	250	250	14.58 c-e	14.69 ab	0.347 e-g	0.333 e-h
Full bloom	250	500	14.36 c-f	14.47 a-d	0.347 e-g	0.340 d-g
Full bloom	500	0	13.61 f-k	13.82 b-g	0.373 a-e	0.360 a-e
Full bloom	500	250	15.77 a	15.34 a	0.300 h	0.300 i
Full bloom	500	500	14.90 a-d	14.74 ab	0.347 e-g	0.327 f-i
One week after full bloom	0	0	13.07 jk	12.96 gh	0.393 ab	0.387 a
One week after full bloom	0	250	14.15 c-h	14.31 b-d	0.360 c-f	0.353 b-f
One week after full bloom	0	500	14.04 d-i	14.04 b-f	0.367 b-f	0.353 b-f
One week after full bloom	250	0	13.28 h-k	13.28 e-g	0.387 a-c	0.380 ab
One week after full bloom	250	250	14.58 c-e	14.63 ab	0.347 e-g	0.333 e-h
One week after full bloom	250	500	14.31 c-g	14.47 a-d	0.347 e-g	0.353 b-f
One week after full bloom	500	0	13.39 g-k	14.16 b-f	0.380 a-d	0.367 a-d
One week after full bloom	500	250	15.66 ab	14.68 ab	0.327 gh	0.307 hi
One week after full bloom	500	500	14.74 b-e	14.74 ab	0.353 d-g	0.326 f-i
Two weeks after full bloom	0	0	12.74 k	12.10 h	0.400 a	0.387 a
Two weeks after full bloom	0	250	14.04 d-i	14.26 b-e	0.367 b-f	0.347 c-g
Two weeks after full bloom	0	500	13.82 e-j	14.04 b-f	0.367 b-f	0.360 a-e
Two weeks after full bloom	250	0	13.18 i-k	13.28 e-g	0.393 ab	0.380 ab
Two weeks after full bloom	250	250	14.47 c-f	14.53 a-c	0.353 d-g	0.327 f-i
Two weeks after full bloom	250	500	14.26 c-g	14.31 b-d	0.360 c-f	0.353 b-f
Two weeks after full bloom	500	0	13.28 h-k	13.61 c-g	0.380 a-d	0.373 a-c
Two weeks after full bloom	500	250	15.01 a-c	14.80 ab	0.340 fg	0.320 g-i
Two weeks after full bloom	500	500	14.69 c-e	14.69 ab	0.353 d-g	0.333 e-h

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

2.2.3. TSS/acid ratio

Fig. (13) and table (7) demonstrates that application date (one week after full bloom and two week after full bloom) gave the lowest values of TSS/acid ratio as compared with application date (full bloom) in first season, but in the second seasons, there no significant difference effect on TSS/acid ratio. Moreover, zinc foliar spray at 500 ppm induced the highest positive effect on TSS/acid ratio in both seasons. Furthermore, B foliar spray at 250 ppm induced the highest values of TSS/acid ratio in both seasons.

The interaction between application dates and foliar spray with zinc reveals that 500 ppm zinc foliar spray at full bloom in both seasons and 500 ppm zinc foliar spray at one week after full bloom in the second season gave similar effect and the highest positive effect on TSS/acid ratio 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 statistically similar and high positive effect on TSS/acid ratio as compared with other combinations in both seasons. Combination of foliar spray with Zn at 500 ppm plus foliar spray with B at 250 ppm exerted the highest positive effect on TSS/acid ratio as compared with other combinations in both seasons.

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 enhancing TSS/acid ratio as compared with other combinations in both seasons.

2.2.4. Ascorbic acid (mg/100 ml berries juice)

It is clear from Fig. (14) and table (7) that neither the three tested factors (application dates, zinc application rates and boron application rates) levelly nor their different combinations succeeded in exerting a distinctive effect on ascorbic acid (mg/100 ml berries juice) of "Early Sweet" grapes.

The obtained results of zinc and / or boron and or application dates as well as their combinations on berries quality go on line with the finding of Abou-Zaid and Shaaban (2019) found that zinc at 100 ppm increased berry weight, number of berries, cluster weight, and cluster length of the Red Roomy grapevine. Also, Belal *et al.* (2023) found that zinc foliar application increased cluster weight, cluster length, and cluster width and decrease clusters compactness and shot berries of ‘Early Sweet’ grapevines. They attribute the reduction of the cluster compactness coefficient to the high efficiency of zinc foliar application in absorbing and transferring water, and minerals to the shoots, thus activating more vegetative growth in full bloom, which lead to changing the competitive balance between blossom clusters and vegetative growth in favor of the latter, causing some flowers to fall and thus reduce the coefficient of cluster compactness as well, which also may be due to the increase in the cluster length. Song *et al.* (2015) reported that zinc foliar spray increased berries quality such as TSS and decreased the concentration of titratable acidity of berries grapevine. Abou El-Nasr *et al.* (2021) revealed that spraying with Zn at 250 ppm significantly increased T.S.S and T.S.S./acid ratio as compared with control in the first season while slight decrease TA in both season of "Crimson" Seedless grapevines. Also, the TSS values in berries were increased in response to the application of zinc on ‘Early Sweet’ grapevines (Belal *et al.,* 2023).

Usha and Singh (2002) noticed that there were no shot berries observed in plants sprayed with boron. Güneş et al (2015) showed that boron application decreased TSS and shot berries ratio and significantly increased number of berries per cluster and cluster weight. Bilir Ekbic *et al.* (2018) reported that boric acid treatments generally had positive effects on berry characteristics (size and color homogeneity, cluster length, width and weight) and the greatest values were obtained from 0.3% boric acid treatment. They found the greatest soluble solid (SS) was obtained from 0.1% boric acid treatment and it was followed by the control treatment but increasing boron to 2 or 3% induced lower (SS), acidity values increased with increasing boron doses. Swathi *et al.,* (2019) mentioned that boron foliar spray increased quality of grapes berries such as TSS and sugars and it decreased titrable acidity. Abou-Zaid and Shaaban (2019) demonstrated that foliar spray with boron at 40 ppm increased cluster weight, cluster length, T.S.S and it reduced Total acidity coefficient as compared with control of "Red Roomy" grapes.

On the other hand, Prabue and Singaram (2002) found that Significant differences in TSS and sugar / acid ratio were observed due to Zn and B application through soil and foliage, either alone or in combinations. The results found that foliar application of $ZnSO_4$ 0.5 % + borax 0.2 % combination applied twice during vegetative (20 days after pruning) and full bloom stages excelled others by having highest Total soluble solids (TSS), Total sugars and Sugar/acid ratio. The acidity was lowest in the same treatment. Application of Zn and B to grapevines significantly reduces the acidity and increase the quality. Nikkhah *et al.* (2013) reported that using different levels of boron and zinc significantly improved the berry quality of grapevines, i.e., berry (number, length, and weight), cluster (length and weight), and TSS.

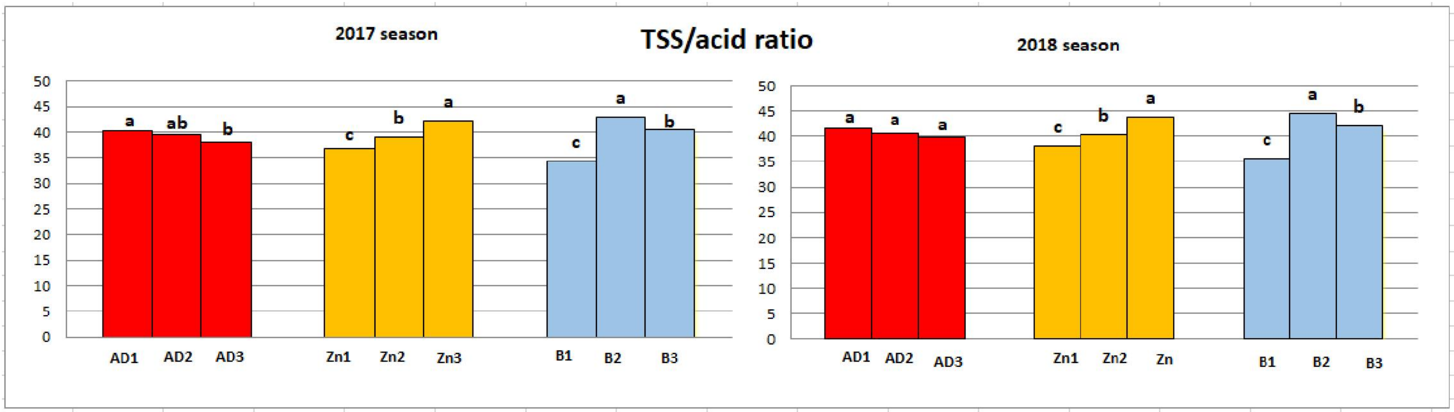

Fig. 13: Effect of application dates (AD), foliar spray of Zn and B on TSS/acid ratio of "Early Sweet" grapes during 2017 and 2018 seasons.

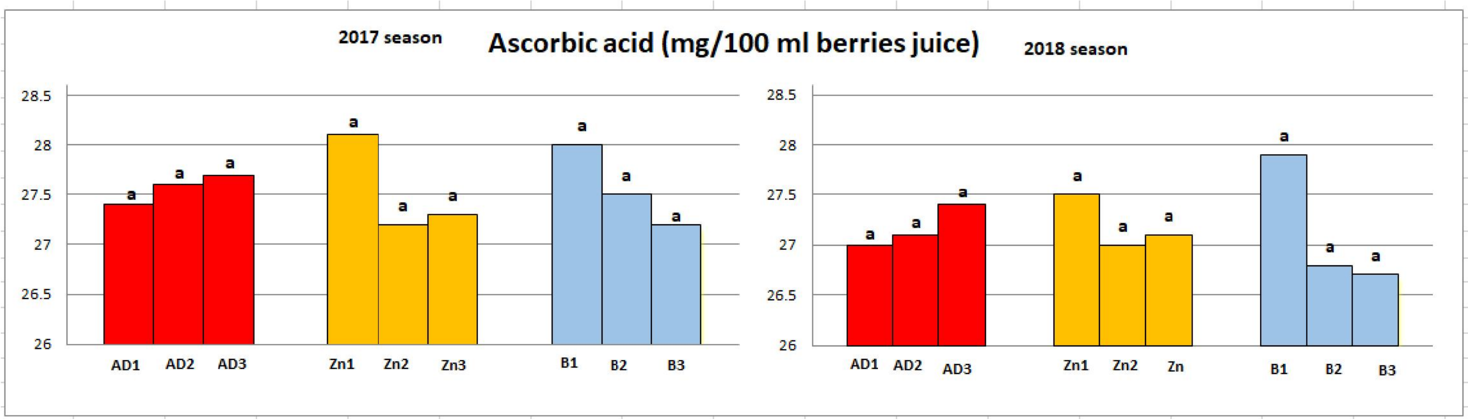

Fig. 14: Effect of application dates (AD), foliar spray of Zn and B on ascorbic acid (mg/100 ml berries juice) of "Early Sweet" grapes during 2017 and 2018 seasons.

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 7: Effect of interactions among application dates, foliar spray of Zn and B on TSS/acid ratio and ascorbic acid (mg/100 ml berries juice) of "Early Sweet" grapes during 2017 and 2018 seasons.

Treatments	**TSS/acid ratio**		**Ascorbic acid (mg/100 ml berries juice)**	
	2017	**2018**	**2017**	**2018**
Effect of interaction between application dates and zinc				
Full bloom + 0ppm Zn	37.2 de	38.7 c-e	27.8 a	27.2 a
Full bloom +250ppm Zn	39.5 b-d	41.0 bc	27.0 a	26.9 a
Full bloom + 500 ppm Zn	44.0 a	45.0 a	27.5 a	27.0 a
One week after full bloom+ 0ppm Zn	37.0 de	38.0 de	28.0 a	27.4 a
One week after full bloom+250ppm Zn	39.3 b-d	40.0 b-d	27.3 a	26.6 a
One week after full bloom+500ppm Zn	41.9 ab	44.0 a	27.4 a	27.3 a
Two weeks after full bloom+ 0ppm Zn	36.0 e	37.2 e	28.6 a	27.8 a
Two weeks after full bloom+ 250ppm Zn	38.1 c-e	40.0 b-d	27.4 a	27.3 a
Two weeks after full bloom+ 500ppm Zn	40.3 bc	42.4 ab	27.1 a	27.0 a
Effect of interaction between application dates and Boron				
Full bloom + 0ppm B	35.1 d	36.5 d	28.0 a	27.8 a
Full bloom +250ppm B	44.7 a	45.6 a	27.3 a	26.8 a
Full bloom + 500 ppm B	41.0 bc	42.6 bc	27.0 a	26.5 a
One week after full bloom+ 0ppm B	34.4 d	35.8 d	28.0 a	27.7 a
One week after full bloom+250ppm B	43.2 ab	44.1 ab	27.7 a	26.8 a
One week after full bloom+500ppm B	40.5 c	42.1 bc	27.1 a	26.8 a
Two weeks after full bloom+ 0ppm B	33.5 d	34.2 d	28.2 a	28.2 a
Two weeks after full bloom+ 250ppm B	41.2 bc	44.0 ab	27.4 a	27.0 a
Two weeks after full bloom+ 500ppm B	39.7 c	41.3 c	27.4 a	26.9 a
Effect of interaction between zinc and Boron				
0 ppm Zn + 0 ppm B	33.0 f	33.2 f	28.6 a	28.1 a
0 ppm Zn +25 0 ppm B	39.0 cd	41.1 c	27.8 a	26.9 a
0 ppm Zn + 500 ppm B	38.1 d	39.6 cd	28.0 a	27.4 a
250 ppm Zn + 0 ppm B	34.3 ef	35.4 ef	27.8 a	27.9 a
250 ppm Zn + 250 ppm B	41.7 b	44.2 b	26.8 a	26.4 a
250 ppm Zn + 5000 ppm B	40.8 bc	41.4 c	27.1 a	26.6 a
500 ppm Zn + 0 ppm B	35.7 e	37.9 de	27.6 a	27.6 a
500 ppm Zn + 250 ppm B	48.3 a	48.5 a	27.9 a	27.2 a
500 ppm Zn + 500 ppm B	42.2 b	44.9 b	26.4 a	26.3 a

Effect of application dates, zinc and Boron

Application dates	**Zn (PPM)**	**B (PPM)**	**TSS/acid ratio**		**Ascorbic acid (mg/100 ml berries juice)**	
			2017	**2018**	**2017**	**2018**
Full bloom	0	0	33.9 i-k	34.7 k-m	28.1 a	28.1 a
Full bloom	0	250	39.4 d-j	41.5 d-h	27.6 a	26.7 a
Full bloom	0	500	38.3 e-h	40.1 f-j	27.8 a	27.0 a
Full bloom	250	0	35.1 h-k	36.4 j-l	27.9 a	28.1 a
Full bloom	250	250	42.1 c-e	44.1 b-g	26.4 a	26.3 a
Full bloom	250	500	41.5 c-f	42.6 c-h	26.6 a	26.4 a
Full bloom	500	0	36.5 g-j	38.4 h-l	27.9 a	27.2 a
Full bloom	500	250	52.5 a	51.3 a	28.0 a	27.4 a
Full bloom	500	500	43.0 cd	45.2 b-e	26.5 a	26.3 a
One week after full bloom	0	0	33.2 jk	33.7 lm	28.4 a	27.6 a
One week after full bloom	0	250	39.4 d-g	40.5 e-j	27.9 a	27.0 a
One week after full bloom	0	500	38.3 e-h	39.8 g-j	27.9 a	27.5 a
One week after full bloom	250	0	34.4 h-k	34.9 k-m	27.8 a	27.6 a
One week after full bloom	250	250	42.2 c-e	44.0 b-g	27.0 a	26.1 a
One week after full bloom	250	500	41.4 c-f	41.1 d-i	27.2 a	26.3 a
One week after full bloom	500	0	35.6 g-k	38.7 h-k	27.7 a	28.0 a
One week after full bloom	500	250	48.0 b	47.9 ab	28.2 a	27.3 a
One week after full bloom	500	500	42.0 c-f	45.4 b-d	26.3 a	26.5 a
Two weeks after full bloom	0	0	31.9 k	31.3 m	29.4 a	28.8 a
Two weeks after full bloom	0	250	38.3 e-h	41.2 d-i	27.9 a	27.1 a
Two weeks after full bloom	0	500	37.8 f-i	39.0 h-k	28.4 a	27.7 a
Two weeks after full bloom	250	0	33.5 jk	34.9 k-m	27.8 a	28.1 a
Two weeks after full bloom	250	250	41.0 c-f	44.6 b-f	27.1 a	26.7 a
Two weeks after full bloom	250	500	39.6 d-g	40.6 e-j	27.4 a	27.0 a
Two weeks after full bloom	500	0	35.0 h-k	36.5 i-l	27.3 a	27.7 a
Two weeks after full bloom	500	250	44.3 bc	46.3 bc	27.4 a	27.0 a
Two weeks after full bloom	500	500	41.6 c-f	44.3 b-g	26.4 a	26.1 a

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

Hegazy *et al.* (2018) found that single or combined application of chelated –Zn and boric acid significantly improved cluster weight and dimensions (length and width) and chemical properties of the grapes in terms of increasing total soluble solids and decreasing total acidity of Thompson seedless grapevines compared with check treatment.

Tadayon & Moafpourian (2019) found that application of zinc and boron both together on grape approximately two weeks before and with the ten days' interval at the start of blooming induced berry weight. Boron foliar application had significant effects on berry number per cluster. Foliar application of 2 gL−1 zinc sulfate and 0.5 gL−1 boric acid had the highest impact on chemical and reproductive characteristics.

Abou-Zaid and Shaaban (2019) reported that (Zn combined with B) had been related with improved cluster parameters and berry quality compared to the control of grapes. Increasing in cluster weight which splashed with B and Zn may be ascribed to increasing a number of berries within the cluster. Also, they found that combined application of Spirulina 1%, zinc 50 ppm and boron 20 ppm twice, one at the beginning of growth and second at the flowering period enhance berries quality of Red Roomy grapevines. Sedri *et al.* (2021) study the effect of zinc, boron, and stages of foliar application on the grapevine and the results showed that Zn and/or B foliar application treatments had a significant effect on soluble solids (TSS) and total acidity (TA). Reduced TA in zinc and boron treated fruits may be due to their utilization in respiration and rapid transformation of organic acids into sugars. Moreover they indicated that Zn and/or B foliar application treatments at two foliar application times in bud swelling stage and after fruit formation had a significant effect on yield components and fruit quality like cluster weight, berry weight, berry size, the yield of each shrub compared to the control. Also, foliar application of zinc sulfate and/or boric acid significantly affected ascorbic acid content and total soluble solids in sweet orange fruits (Walli *et al.,* 2022). But in this study application dates, zinc application rates and boron application rates) levelly nor their different combinations succeeded in exerting a distinctive effect on ascorbic acid (mg/100 ml berries juice) of "Early Sweet" grapes.

4. Conclusion

In summary, this study has applied foliar sprays of zinc and boron, separately or in combination, at various application dates, to improve the cluster quality of "Early Sweet" grapevines. The outcomes showed that the combination of 500 ppm Zn and 250 ppm B foliar spray at full bloom outperformed the other combinations in terms of improving the cluster and berry quality parameters in terms of increased Cluster weight, length and width, number of berries per cluster, total soluble solids, and total acidity reduction. For "Early Sweet" grapevines grown in Egypt, it is therefore advised to administer foliar spray containing 500 ppm of zinc and 250 ppm of zinc once the vines reach full bloom.

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