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Effect of Boron and Ascorbic Acid on Growth, Flowering and Productivity of Almond Trees under Rain-fed Conditions

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ABSTRACT

The present study was conducted in a private almond orchard at Marsa Matrouh Governorate, Egypt during three consecutive seasons of 2021, 2022 and 2023 of about 10 years old, "Umm al-Fahm" almond trees (*Prunus dulcis* (Miller) D.A. Webb) budded on Bitter almond rootstock and planted at 7x7 m apart. The trees were grown in sandy loam soil under rainfed conditions. This investigation was designed as in a factorial experiment with two factors i.e. the first factor six foliar spray treatments i.e. control, boric acid (H_3 BO_3) (B) at two concentrations (150 and 300 ppm), ascorbic acid (C_6 H_8 O_6) (AsA) at two concentrations (750 and 1000 ppm) and boric acid (B) at 300 ppm plus ascorbic acid (AsA) at 1000 ppm and the second factor consisted of two application dates of the tested treatments, 15th September and 15th December on vegetative growth characteristics, fruit set percentage, yield and fruit quality. The results showed 300 ppm boron plus 1000 ppm ascorbic acid foliar spray gave the highest values for vegetative growth characteristics (shoot length increase, number of shoots/branch, number of leaves/shoot, leaf chlorophyll content and leaf area), fruit set percentage, yield , fruit quality (kernel weight, kernel length and kernel width) application date of foliar spray in 15th September had the highest significant effect on number of shoots/branch, leaf chlorophyll content in both seasons, and both leaf area and fruit set percentage in first season) fruit quality (kernel weight and kernel length in both seasons) than that foliar sprays on 15th December , but had no significant effect on shoot length increase, number of leaves per shoot, yield , kernel weight in both seasons also fruit set percentage in second season. Furthermore, the interaction between foliar spray treatments and application dates of foliar sprays indicated that 300 ppm boric acid plus 1000 ppm ascorbic acid foliar spray at 15th September recorded the highest values for vegetative growth characteristics fruit set percentage, yield and fruit quality.

Keywords: Umm al-Fahm, almond tree, Boron, Ascorbic acid, vegetative growth, productivity

1. Introduction

Almond *(Prunus dulcis* (Miller) D.A. Webb) is a member of the family Rosaceae grown in Mediterranean climates and it is relatively drought resistant **(**Palasciano *et al.,* 2014).

Almond planted in both north and western coast, special Marsa Matrouh condition, Egypt, it depend on rain-fed irrigation, sometimes need supplementary irrigation if necessary, in mid-November trees receive the winter horticultural practices before the rains fall, where almond trees are fertilized with organic manure, chemical fertilizers and trees do not receive any fertilization after that (Salama, 2023). Under rainfed conditions in Egypt, almond trees suffering from a lack of nutrients and this appears on the growth, productivity and fruit quality, especially boron. In additions, the horticultural practices development in almond groves is necessary for those rain-fed conditions to improve almond production such as foliar spray of boron and ascorbic acid and study time of foliar spray application. Boron is a 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 (White & Zasoski, 1999 and Tavallali & Rahemi, 2007). Boron has been playing an essential role in fertility (Christensen *et al.,* 2016) and boron is a nutrient that influences the effective of

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pollination period in almond. It is well known that boron is important for pollen germination and pollen tube growth, for successful growth of the pollen tube through the stigma (Lovatt and Dugger, 1984). Boron deficiency causes reduced pollen production and poor fruit set. Because, boron is required in stigma and styles to physiologically inactivate callus present in pollen tube walls (Lewis, 1980). Foliar sprays of boron increase pollen germination in almond (Nyomora *et al.,* 2000 and Lee *et al.,* 2000) on pear. Moreover, born increase fruit set in almond (Nyomora *et al.,* 1997 and Silva *et al.,* 2003). Meyer *et al.* (1998) showed that N, P, K and B treatments increased yield and weight of kernel of almond trees when foliar spray of N, P, K and B were applied at pink tip pre-bloom, 30 days after pre-bloom and 60 days after pre-bloom. Daood and Shahin (2006) reported that foliar spray of combination among 1.0% magnesium sulphate, 0.5% boric acid, 500ppm ascorbic acid and 200 ppm vitamin B complex improved growth, nutritional status, yield and fruit quality of "Canino" apricot. Kizildemir *et al.* (2013) stated that Boron application improved fruit set and increased leaf B concentration on 'Nonpareil' almond trees. Abdel-Karim *et al.* (2015) mentioned that foliar spray of boron and zinc improved leaf chlorophyll content, fruit set and fruit characteristics of avocado trees. Maneesh *et al.* (2018) found that foliar spray of B + Zn enhanced vegetative growth parameter, fruit set, yield and fruit quality of pomegranate. Ehsanullah *et al.* (2020) mentioned that the combined foliar application of 0.5% Zinc sulphate and 0.3% Borax showed best results in vegetative growth, yield and quality of apple. Shaymaa *et al.* (2022) indicated that foliar spraying of B at 100 mg/L increased all vegetative growth characteristics (stem length, stem diameter, number of branches/seedling, number of leaves / seedling, chlorophyll, leaf area, leaf fresh weight and leaf dry weight) of almond. In addition, antioxidants such as ascorbic acids are safe for humans and environment (Elade, 1992). It has also been reported that application of exogenous ascorbic acid can reduce oxidative stresses (Shalata and Neumann, 2001). Ascorbic acid has been shown to play multiple roles in plant growth, such as in cell division, cell wall expansion and other developmental processes (Lee and Kader, 2000 & Pignocchi and Foyer, 2003). Ascorbic acid functions as enzymatic cofactor, moreover, it plays important roles in many physiological processes, including photosynthesis, photo-protection, stress resistance, biosynthesis of hormones and cell wall constituents (Davey *et al.,* 2000 and Conklin and Barth, 2004). Ascorbic acid has axenic action. It has a synergistic effect on improving growth, yield and fruit quality of fruit crops (Barth *et al.,* 2006). Abd-El-Rhman *et al.* (2017) reported that foliar spray ascorbic acid enhanced yield and fruit quality of Manfaloty pomegranate trees. Atef (2018) pointed out that foliar spray ascorbic acid improved growth, yield fruit quality of Wonderful pomegranate trees. Al-douri and Basheer (2021) illustrated that foliar spray of ascorbic acid at 150-300 mg/L enhanced the vegetative growth and nutrients content of bitter almond seedlings. Raad *et al.* (2021) indicated that foliar spray of 150 mg/L ascorbic acid increased significantly the shoot length, leaf area, chlorophyll content, fruit set %, number of fruits per tree, fruit weight and yield of tree of pear trees. On the other hand, Al-Douri and Jassim (2012) mentioned that foliar spray combined of B at 50 mg/L plus ascorbic acid at 250 mg/L was the best treatment in enhancing leaf area, leaf chlorophyll and stem diameter of pomegranate trees.

Moreover, time of application of B is important to enhance fruit set and yield. Boron spray applied during fall or spring to deciduous fruit trees have positive effective in increasing fruit set, yield and fruit quality (Hanson, 1991). Furthermore, Agnes *et al.* (1997) indicated that early fall foliar application of boron significantly increased fruit set and yield. It was concluded that fall foliar-applied boron is a useful fertilization strategy that can be used and that boron applied at 245 and/or 490 ppm significantly increased fruit set and yield of almond trees.

The aim of the present research was to study the effect of foliar spraying of boric acid and/or ascorbic acid on vegetative growth, yield and fruit quality as well as two application dates of foliar sprays on almond tree under Marsa Matrouh rain fed conditions.

2. Materials and Methods

This investigation was carried out during two consecutive seasons of 2021, 2022 and 2023 on healthy "Umm al-Fahm" almond trees *(Prunus dulcis* (Miller) D.A. Webb) that were about 10 years old, budded on bitter almond rootstock and planted at 7x7 m apart. Trees were grown on sandy loam soil under rainfed conditions in a private almond orchard in Marsa Matrouh Governorate, Egypt. Some properties of the experimental soil are shown in Table (1).

Table 1: Analysis of experimental soil.

Soil depth (cm)	Texture class	pH Soil past	E.Ce (dSm^{-1})
0-30	Sandy loam	7.8	1.0
30-60	Sandy loam	7.5	0.7

Soil depth (cm)	Soluble cations (meq/l)				Soluble anions (meq/l)			
	Ca^{++}	K^{+}	Na^{+}	Mg^{++}	Cl^{-}	$SO_4^{=}$	HCO_3^{-}	$CO_3^{=}$
0-30	3	0.5	5.5	1	5	3	2	-
30-60	2	0.16	4.04	0.8	3.7	2.3	1	-

Weather data for the almond orchard, Marsa Matrouh Governorate, Egypt during the 2021, 2022 and 2023 seasons showed in Table 2, from Central Laboratory for Agriculture Climate, Agricultural Research Center, Egypt.

Table 2: Average of temperature, relative humidity, and amount of precipitation of almond orchard during 2021, 2022 and 2023 seasons.

Months	Average Temperature (°C)	Average Relative Humidity (%)	Precipitation (mm)
	2021-2022		
November	20.99	66.83	10.60
December	16.33	64.95	25.30
January	13.33	72.39	124.60
February	13.83	73.65	36.80
March	13.51	73.71	55.30
Total	15.60	70.31	252.60
	2022-2023		
November	19.99	64.69	7.00
December	18.35	69.06	9.50
January	16.02	69.72	146.70
February	14.46	69.42	89.40
March	16.41	70.78	8.00
Total	17.04	68.73	260.60

Central Laboratory for Agriculture Climate, Agricultural Research Center, Egypt.

The present study was designed as in a factorial experiment with two factors i.e. the first factor consists six foliar spray treatments i.e. control, boric acid ($H_3 BO_3$) (B) at two concentrations (150 and 300 ppm), ascorbic acid ($C_6 H_8 O_6$) (As A) at two concentrations (750 and 1000 ppm) and boric acid (B) at 300 ppm plus ascorbic acid (As A) at 1000 ppm (chemicals mixed done before foliar spray directly), and the second factor consist of two application dates of the tested treatments, 15th September and 15th December. Two factors arranged in a randomized complete block design with three replicates for each treatment and each replicate was represented by one tree. Almond trees healthy, nearly in shape and size and productivity as well as received the same horticulture practices, were subjected to foliar application was done in the early morning, treatments were performed by spraying 5 liter per tree of the boric acid ascorbic acid with a hand-pump knapsack sprayer, and Tween-20 was added at 0.1% as a surfactant to the spray solution. In mid-November of 2021 and 2022 seasons, trees receive the winter horticultural practices before the rains fell, where almond tree (each tested tree) was fertilized with a

mixture of sheep manure fertilizer (20 kg/tree sheep manure) mixed with chemical fertilizers (1 kg/tree super calcium phosphate (45% P_2O_5) + 250 g/tree potassium sulfate + 500 g/tree sulfur (95 % S) + 250 g/tree sulfur coated urea (36.5% urea and 16% S). Chemical analysis of the tested sheep manure was presented in Table (3).

Table 3: Chemical analysis of sheep manure

N (%)	P (%)	K (%)	Ca (%)	Mg (%)	Fe ppm	Mn ppm	Zn ppm	Organic matter Content (%)
1.71	0.61	0.61	0.33	0.38	871	160	15	50.10

A Mixture of sheep manure and chemical fertilizers was applied in the two trenches (100 cm length x 30 cm width x 40 cm depth) dug on both sides of the tree at a distance of 1 m from the tree trunk and covered with trench soil. The treated trees were evaluated through the following determinations:

2.1. Vegetative growth:

In early of both seasons, four branches, nearly uniform in diameter and length were labeled on different treated tree directions. Twenty developing vegetative shoots per tree (five shoots on every branch) were tagged to determine the mean increase in shoot length. At the harvest time the average number of new shoots per branch were counted and recorded. Moreover, leaves of tagged shoots were counted and the increase in their number was determined and recorded. Moreover, leaf area; after harvest time, twenty mature leaves (the third one from the base of the tagged, non-fruiting, shoots) were collected for estimating leaf area using area meter (model cl-203, USA). Leaf chlorophyll content was determined by Minolta chlorophyll meter SPAD-502.

2.2. Fruit set percentage and yield (kg/tree):

The number of fruitlets per cluster was counted after three weeks of full bloom to determine the initial number of set fruitlets. The initial fruit set was calculated as a percentage. In each season, at harvest time (August, 15th), yield (kg/tree) was weighed and recorded.

2.3. Fruit quality:

Twenty ripen fruits were taken at harvest when the almonds were found to be ripe, at least 80% open hull from each treated tree. The fruit separated to obtain the almond kernels then the determination of the following physical properties i.e. kernel weight (g), kernel length (cm), and kernel width (cm).

2.4. **Statistical analysis:**

The obtained data in 2022 and 2023 seasons were subjected to analysis of variance according to Clarke and Kempson (1997). Means were differentiated using the Range test at the 0.05 level (Duncan, 1955)

3. Results and Discussion

3.1. Vegetative growth characteristics:

3.1.1. Shoot length increase (cm):

Table, 4 illustrates that 300 ppm boron plus 1000 ppm ascorbic acid foliar spray gave the highest increment in shoot length followed in descending by ascorbic acid 1000 ppm, ascorbic acid 750 ppm and boric acid at 300 and boric acid at 150 ppm, respectively in both seasons of study. However, the application date of foliar spraying had no significant effect on shoot length increase in both seasons. Furthermore, the interaction between treatments foliar spray combined with application dates of foliar spray resulted in 300 ppm boric acid plus 1000 ppm ascorbic acid foliar spray at 15th September and at 15th December and ascorbic acid at 1000 ppm at 15th September gave the same significant values and proved to be the best interaction in this regard in the first season. But 300 ppm boric acid plus 1000 ppm ascorbic acid foliar spray at 15th September and at 15th December gave the highest value in the second season.

Table 4: Effect of application dates of foliar sprays, boron and ascorbic acid rates as well as their interactions on shoot length increase of almond trees (2022 and 2023 seasons).

Foliar sprays	Shoot length increase (cm)					
	2022			2023		
	Application date of foliar spray			Application date of foliar spray		
	15th September	15th December	Mean	15th September	15th December	Mean
Control	21.0 f	21.6 ef	**21.3 E**	21.3 g	22.0 fg	**21.6 E**
150 ppm Boron (B)	23.0 de	25.0 c	**24.0 D**	25.0 cd	23.0 ef	**24.0 D**
300 ppm Boron	24.0 cd	27.0 b	**25.5 C**	26.0 c	23.6 de	**24.8 CD**
750 ppm Ascorbic acid (AsA)	27.0 b	24.0 cd	**25.5 C**	23.3 ef	28.3 b	**25.8 C**
1000 ppm Ascorbic acid	29.0 a	27.0 b	**28.0 B**	26.3 c	26.3 c	**28.1 B**
300 ppm (B) + 1000 ppm (AsA)	30.3 a	30.0 a	**30.1 A**	31.3 a	30.0 a	**30.6 A**
Mean	**25.73 A**	**25.70 A**		**26.1 A**	**25.5 A**	

Means followed by the same letter (s) within each row, column or interaction are not significantly different at 5% level

3.1.2. No. of shoots/branch:

Results in Table (5) indicate that the highest number of shoots/branch was found in almond trees treated by 300 ppm boron and 1000 ppm ascorbic acid foliar spray as compared with control in both seasons. Furthermore, Table (5) shows that application dates of foliar sprays in 15th September had the highest significant effect on number of shoots/branch than those foliar sprays on 15th December.

Table 5: Effect of application dates of foliar sprays, boron and ascorbic acid rates as well as their interactions on number of shoots/branch of almond trees (2022 and 2023 seasons).

Foliar sprays	Number of shoots/branch					
	2022			2023		
	Application date of foliar spray			Application date of foliar spray		
	15th September	15th December	Mean	15th September	15th December	Mean
Control	7.3 e	6.0 f	**6.6 E**	7.3 gh	7.0 H	**7.1 D**
150 ppm Boron (B)	8.3 cde	7.6 de	**8.0 D**	9.6 def	8.6 fgh	**9.1 C**
300 ppm Boron	8.6 cd	8.0 de	**8.3 D**	10.6 cde	9.0 efg	**9.8 C**
750 ppm Ascorbic acid (AsA)	11.0 b	9.3 c	**10.1C**	12.6 ab	11.0 bcd	**11.8 B**
1000 ppm Ascorbic acid	12.0 ab	11.0 b	**11.5 B**	13.0 a	12.0 abc	**12.5 AB**
300 ppm (B) + 1000 ppm(AsA)	12.6 a	13.0 a	**12.8 A**	13.3 a	13.3 a	**13.3 A**
Mean	**10.0 A**	**9.1 B**		**11.1 A**	**10.2 B**	

Means followed by the same letter (s) within each row, column or interaction are not significantly different at 5% level

The interaction between all tested foliar sprays combined with application dates of foliar sprays illustrates that the highest increment in number of shoots/branch was recorded by 300 ppm boric acid plus 1000 ppm ascorbic acid foliar spray at 15th September and at 15th December in the first season. But

300 ppm boric acid plus 1000 ppm ascorbic acid foliar sprays at 15th September and at 15th December and ascorbic acid foliar sprays at 15th September gave the same and high values in the second season.

3.1.3. Number of leaves/shoot:

Data presented in Table (6) show that the highest increment in number of leaves per shoot values were recorded with 300 ppm boron and 1000 ppm ascorbic acid foliar spray as compared with control in both seasons. Furthermore, application dates of foliar spray had no significant effect on number of leaves per shoot in the two seasons. The interaction of all tested foliar sprays combined with application dates of foliar sprays reveals that the highest increment in number of leaves per shoot were scored with 300 ppm boric acid plus 1000 ppm ascorbic acid foliar sprays at 15th September and at 15th December and ascorbic acid foliar sprays at 15th September gave the same and the best interaction in this regard in the both seasons.

Table 6: Effect of application dates of foliar sprays, boron and ascorbic acid rates as well as their interactions on number of leaves/shoot of almond trees (2022 and 2023 seasons).

Foliar sprays	Number of leaves/shoot					
	2022			2023		
	Application date of foliar spray			Application date of foliar spray		
	15th September	15th December	Mean	15th September	15th December	Mean
Control	16.0 ef	15.3 f	**15.6 D**	15.3 i	16.6 h	**16.0 F**
150 ppm Boron (B)	16.6 def	17.0 de	**16.8 C**	17.3 gh	18.0 fg	**17.6 E**
300 ppm Boron	17.6 cd	17.3 de	**17.5 C**	19.0 de	18.3 ef	**18.6 D**
750 ppm Ascorbic acid (AsA)	20.0 ab	18.6 bc	**19.3 B**	21.0 b	19.3 cd	**20.1 C**
1000 ppm Ascorbic acid	20.6 a	19.0 bc	**19.8 B**	22.0 a	20.0 c	**21.0 B**
300 ppm (B) + 1000 ppm (AsA)	21.3 a	21.3 a	**21.0 A**	22.3 a	22.6 a	**22.5 A**
Mean	**18.6 A**	**18.1 A**		**19.5 A**	**19.1 A**	

Means followed by the same letter (s) within each row, column or interaction are not significantly different at 5% level

3.1.4. Leaf chlorophyll content:

Table (7) indicates that 300 ppm boron and 1000 ppm ascorbic acid foliar spray recorded the highest increase in leaf chlorophyll content value followed by ascorbic acid at 1000 ppm, ascorbic acid at 750 ppm, boron at 300 ppm and boron at 150 ppm, respectively in both seasons. Furthermore, application dates of foliar sprays in 15th September had the highest significant effect on leaf chlorophyll content value than those foliar sprays on 15th December in both seasons. The interaction of all tested foliar sprays combined with application dates of foliar sprays reveals that the highest increment in leaf chlorophyll content was recorded with 300 ppm boric acid plus 1000 ppm ascorbic acid foliar spray at 15th September and at 15th December in the both seasons.

3.1.5. Leaf area (cm^2):

Table (8) indicates that 300 ppm boron and 1000 ppm ascorbic acid foliar spray gave the highest increment in leaf area as compared with control in both seasons. Furthermore, application dates of foliar sprays on 15th September had the highest significant effect on leaf area value than those foliar sprays on 15th December in the first seasons and no significant effect on leaf area in second season. The interaction between all tested foliar sprays combined with application dates of foliar sprays reveals that the highest increment in leaf area was recorded with 300 ppm boric acid plus 1000 ppm ascorbic acid foliar spray at 15th September and at 15th December in the first season, but 300 ppm boric acid plus 1000 ppm ascorbic acid foliar spray at 15th September gave the highest value in the second seasons.

Table 7: Effect of application dates of foliar sprays, boron and ascorbic acid rates as well as their interactions on leaf chlorophyll of almond trees (2022 and 2023 seasons).

Foliar sprays	Leaf chlorophyll					
	2022			2023		
	Application date of foliar spray			Application date of foliar spray		
	15th September	15th December	Mean	15th September	15th December	Mean
Control	34.66 g	33.66 h	**34.16 F**	35.00 g	34.66 g	**34.83 F**
150 ppm Boron (B)	38.66 e	37.33 f	**38.00 E**	39.66 ef	38.66 f	**39.16 E**
300 ppm Boron	42.00 d	39.00 e	**40.50 D**	41.00 d	40.33 de	**40.66 D**
750 ppm Ascorbic acid (As A)	43.66 c	43.66 c	**42.66 C**	43.33 c	41.00 d	**42.16 C**
1000 ppm Ascorbic acid	46.33 b	43.00 c	**44.66 B**	44.66 b	42.33 c	**43.50 B**
300 ppm B + 1000 ppm As A	47.00 a	47.33 a	**47.16 A**	46.33 a	46.66 a	**46.50 A**
Mean	**42.05 A**	**40.33 B**		**41.66 A**	**40.61 B**	

Means followed by the same letter (s) within each row, column or interaction are not significantly different at 5% level

Table 8: Effect of application dates of foliar sprays, boron and ascorbic acid rates as well as their interactions on leaf area of almond trees (2022 and 2023 seasons).

Foliar sprays	Leaf area (cm^2)					
	2022			2023		
	Application date of foliar spray			Application date of foliar spray		
	15th September	15th December	Mean	15th September	15th December	Mean
Control	5.50 g	6.00 g	**5.75 E**	6.50 g	5.50 g	**6.00 D**
150 ppm Boron (B)	8.00 ef	7.66 f	**7.83 D**	8.00 f	8.66 ef	**8.33 C**
300 ppm Boron	9.66 cd	8.66 def	**9.16 C**	9.00 def	9.00D ef	**9.00 C**
750 ppm Ascorbic acid (AsA)	10.00 bc	9.00 cde	**9.50 BC**	9.66 de	11.00 bc	**10.33 B**
1000 ppm Ascorbic acid	11.00 ab	9.66 cd	**10.33 B**	10.00 cd	12.00 ab	**11.00 B**
300 ppm B + 1000 ppm AsA	11.33 a	11.66 a	**11.50 A**	13.00 a	12.00 ab	**12.50 A**
Mean	**9.250 A**	**8.777 B**		**9.361 A**	**9.694 A**	

Means followed by the same letter (s) within each row, column or interaction are not significantly different at 5% level

Concerning, the positive results of foliar sprays of boric acid and/or ascorbic acid on vegetative growth are in harmony with previous studies of Daood and Shahin (2006) on apricot; Abdel-Karim *et al.* (2015) on avocado trees; Maneesh *et al.* (2018) on pomegranate trees; Ehsanullah *et al*. (2020) on apple. Furthermore, Al-douri and Basheer (2021) and Shaymaa *et al.* (2022) they indicated that boron foliar application significantly increased vegetative growth of almond. On the other hand, Fayed (2010) who mentioned that foliar of application ascorbic plus citric acid enhanced vegetative growth parameters of pomegranate trees. Moreover, El-Sayed *et al.* (2014) reported that ascorbic acid treatments enhanced leaf area and total chlorophyll of Manzanillo olive trees. Atef (2018) stated that foliar sprays with ascorbic acid enhanced growth parameters of "Wonderful" pomegranate trees.

Moreover, Raad *et al.* (2021) found that foliar spray of 150 mg/L ascorbic acid increased significantly the shoot length, leaf area and leaf chlorophyll content of pear trees. Moreover, Al-Douri and Jassim (2012) they mentioned that foliar spray combined of B at 50 mg/L plus ascorbic acid at 250 mg/L was the best treatment in enhancing leaf area, leaf chlorophyll and stem diameter of pomegranate trees. The enhancement effect of ascorbic acid on vegetative growth parameters may be attributed that ascorbic acid has positive action in catching all free radicals produced during plant metabolism (Shalata and Neumann, 2001). Moreover, ascorbic acid has an axenic action and synergistic effect on tree growth (Barth *et al.,* 2006). Ascorbic acid increased IAA content, which stimulates cell division as well as cell enlargement and this in turn in improved plant growth (Hassanein *et al.,* 2009 and Abd-El Hamid, 2009). Ascorbic acid may serve as a potential growth regulator to enhance stress resistance in several species (Shalata and Peter, 2001). Besides, foliar application of ascorbic acid had positive effect on growth parameter and increases in photosynthesis (Barth *et al.,* 2006).

The obtained results regarding the effect of application dates of foliar sprays on vegetative growth go in line with the findings of Agnes *et al.* (1997) on almond trees.

3.2. Fruit set percentage and yield (kg/tree):

3.2.1. Fruit set percentage:

It is clear from Table (9) that 300 ppm boron and 1000 ppm ascorbic acid foliar spray produced the highest fruit set percentage as compared with the control in both seasons. On the other hand, other treatments gave an intermediate effect in this respect. Furthermore, application dates of foliar sprays applied on 15th September had the highest significant effect on fruit set percentage than those foliar sprays on 15th December in the first season. But in the second season, application dates of foliar sprays had no significant effect on fruit set percentage. The interaction between all tested foliar sprays combined with application dates of foliar sprays illustrates that the highest increment in fruit set percentage was recorded with 300 ppm boric acid as well as 300 ppm boric acid plus 1000 ppm ascorbic acid foliar spray at 15th September in the first season and 300 ppm boric acid plus 1000 ppm ascorbic acid foliar spray on 15th September and 15th December in the second season gave the same and the highest values in this respect.

Table 9: Effect of application dates of foliar sprays, boron and ascorbic acid rates as well as their interactions on fruit set percentage of almond trees (2022 and 2023 seasons).

Foliar sprays	Fruit set (%)					
	2022			2023		
	Application date of foliar spray			Application date of foliar spray		
	15th September	15th December	Mean	15th September	15th December	Mean
Control	17.66 h	18.00 h	**17.83 E**	18.33 f	19.00 f	**18.66 E**
150 ppm Boron (B)	26.66 c	23.00 f	**24.83 C**	27.33 b	24.00 d	**25.66 C**
300 ppm Boron	28.33 b	25.33 de	**26.83 B**	29.66 a	25.66 c	**27.66 B**
750 ppm Ascorbic acid (AsA)	21.66 g	25.00 e	**23.33 D**	26.00 bc	26.00 bc	**24.16 D**
1000 ppm Ascorbic acid	23.33 f	26.00 cd	**24.66 C**	23.66 de	27.00 bc	**25.33CD**
300 ppm (B) + 1000 ppm (AsA)	29.33 a	28.00 b	**28.66 A**	30.00 a	29.00 a	**29.50 A**
Mean	**24.50 A**	**24.22 B**		**25.22 A**	**25.11 A**	

Means followed by the same letter (s) within each row, column or interaction are not significantly different at 5% level

3.2.2. Yield (kg)/tree

Table (10) shows that 300 ppm boron and 1000 ppm ascorbic acid foliar spray produced the highest almond tree yield as compared with the control in both seasons. On the other hand, other treatments gave an intermediate effect in this respect. Furthermore, application dates of foliar sprays had no significant effect on yield in both seasons. The interaction between all tested foliar sprays combined with application dates of foliar sprays illustrates that the highest yield was recorded with 300 ppm boric acid as well as 300 ppm boric acid plus 1000 ppm ascorbic acid foliar spray at 15th September in the first season and 300 ppm boric acid plus 1000 ppm ascorbic acid foliar spray on 15th September and 15th December in the second season gave the same and the highest values in this respect.

Table 10: Effect of application dates of foliar sprays, boron and ascorbic acid rates as well as their interactions on yield of almond trees (2022 and 2023 seasons).

Foliar sprays	Yield (kg)					
	2022			2023		
	Application date of foliar spray			Application date of foliar spray		
	15th September	15th December	Mean	15th September	15th December	Mean
Control	1.96 e	2.13 e	**2.05 D**	2.00 g	2.10 G	**2.05 E**
150 ppm Boron (B)	3.30 bc	2.80 d	**3.05 C**	3.23 bc	2.70 ef	**2.96 CD**
300 ppm Boron	3.96 a	2.96 cd	**3.46 B**	4.03 a	2.90 de	**3.46 B**
750 ppm Ascorbic acid (AsA)	2.73 d	3.16 bcd	**2.95 C**	2.60 f	3.00 cd	**2.80 D**
1000 ppm Ascorbic acid	3.00 bcd	3.43 b	**3.21 BC**	2.80 def	3.40 b	**3.10 C**
300 ppm (B) + 1000 ppm (AsA)	3.96 a	3.90 a	**3.93 A**	3.93 a	3.83 a	**3.88 A**
Mean	**3.15 A**	**3.06 A**		**3.10 A**	**2.98 A**	

Means followed by the same letter (s) within each row, column or interaction are not significantly different at 5% level

The obtained results regarding the effect of foliar sprays of boric acid and/or ascorbic acid on fruit set and yield go in line with finding of Hanson (1991); Nyomora *et al.* (1997) and Silva *et al.* (2003) they found that boron application increase yield in several fruit. Moreover, Blevins *et al.* (1998) and Hu *et al.* (1997) indicated that foliar applications of boron were effective in nut trees, such as almond, and sour cherry. Kizildemir *et al.* (2013) conducted that Boron application improved fruit set and yield of 'Nonpareil' almond trees. Also, Abdel-Karim *et al.* (2015) mentioned that foliar spray of boron and zinc improved fruit set and fruit characteristics of avocado trees. Moreover, Al-Douri and Jassim (2012) reported that foliar spraying with of ascorbic acid improved fruit set and yield of pomegranate trees. The enhancement effect of ascorbic acid on fruit set and yield may be attributed to the fact that ascorbic acid increased leaf chlorophyll content (Fayed, 2010). This led to enhanced of photosynthesis process (Barth *et al.,* 2006) which led to more carbohydrate production and that reflected in higher yield. Besides, ascorbic acid increased IAA content which stimulates cell division as well as cell enlargement (Hassanein *et al.* 2009 and Abd-El Hamid 2009). The obtained results regarding the effect of ascorbic acid on yield go in line with the findings of Fayed (2010) on pomegranate trees and Abd-El-Rhman *et al.* (2017) on "Manfalouty" pomegranate trees and Atef (2018) on "Wonderful" pomegranate trees.

On the other hand, the obtained results regarding the effect of application dates of foliar sprays on fruit set and yield are in line with the findings of Agnes *et al.* (1997) they mentioned that early fall foliar application of boron significantly increased fruit set and yield. It is concluded that fall foliar-applied boron is a useful fertilization strategy that can be used and that boron applied at 245 and/or 490 ppm significantly increased fruit set and yield of almond trees.

3.3. Fruit quality:

3.3.1. Kernel weight (g):

Table (11) illustrates that 300 ppm boron and 1000 ppm ascorbic acid foliar spray resulted in the highest kernel weight as compared with control in both seasons. On the other hand, other treatments gave an intermediate effect in this respect. Moreover, application dates of foliar sprays on 15th September had the highest significantly effect on kernel weight than those treatments foliar sprays applied on 15th December in both seasons. Concerning the interaction between all tested foliar sprays combined with application dates of foliar spray illustrates that 300 ppm boric acid plus 1000 ppm ascorbic acid foliar spray on 15th September proved to be the best interaction in this regard.

Table 11: Effect of application dates of foliar sprays, boron and ascorbic acid rates as well as their interactions on kernel weight of almond trees (2022 and 2023 seasons).

Foliar sprays	Kernel weight (g)					
	2022			2023		
	Application date of foliar spray			Application date of foliar spray		
	15th September	15th December	Mean	15th September	15th December	Mean
Control	1.08 f	1.02 f	**1.05 D**	1.12 f	1.00 G	**1.06 D**
150 ppm Boron (B)	1.47 c	1.25 e	**1.36 C**	1.32 de	1.31 de	**1.31 C**
300 ppm Boron	1.59 b	1.27 e	**1.43 B**	1.43 c	1.35 cde	**1.39 B**
750 ppm Ascorbic acid (AsA)	1.35 de	1.31 e	**1.33 C**	1.27 e	1.39 cd	**1.33 C**
1000 ppm Ascorbic acid	1.43 cd	1.32 de	**1.37 BC**	1.31 de	1.31 de	**1.31 C**
300 ppm (B) + 1000 ppm (AsA)	1.87 a	1.62 b	**1.75 A**	1.90 a	1.72 b	**1.81 A**
Mean	**1.46 A**	**1.30 B**		**1.39 A**	**1.34 B**	

Means followed by the same letter (s) within each row, column or interaction are not significantly different at 5% level

3.3.2. Kernel length (cm):

Table (12) indicates that 300 ppm boron and 1000 ppm ascorbic acid foliar spray recorded the highest kernel length as compared with control in both seasons. On the other hand, other treatments gave an intermediate effect in this respect. Moreover, application dates of foliar sprays on 15th September resulted in greater kernel length than those foliar sprays on 15th December in both seasons. The interaction between all tested foliar sprays combined with application dates of foliar sprays reveals that the highest kernel length was recorded with 300 ppm boric acid plus 1000 ppm ascorbic acid foliar spray on 15th September.

3.3.3. Kernel width (cm):

It is clear from Table (13) that 300 ppm boron and 1000 ppm ascorbic acid foliar spray produced the widest kernel as compared with control in both seasons. Furthermore, application dates of foliar sprays had no significant effect on kernel width in both seasons. The interaction between all tested foliar sprays combined with application dates of foliar sprays illustrates that the highest kernel width was recorded with 300 ppm boric acid plus 1000 ppm ascorbic acid foliar spray on 15th September in both seasons.

The obtained results regarding the effect of boron and/or ascorbic acid on fruit quality go in line with the findings of Meyer *et al.* (1998) on almond; Daood and Shahin (2006) on apricot; Abdel-Karim *et al.* (2015) on avocado; Maneesh *et al.* (2018) on pomegranate; Ehsanullah *et al.* (2020) on apple. Atef (2018) mentioned that foliar sprays of ascorbic acid improved fruit quality of pomegranate fruit. The enhancement effect of ascorbic acid on fruit quality may be attributed that firstly, ascorbic acid increased leaf area and leaf chlorophyll content. This is lead to enhanced photosynthesis process (Barth

et al., 2006), which reflected in more carbohydrate production and consequently improved fruit quality. Secondly, ascorbic acid increased IAA content which stimulates cell division as well as cell enlargement (Hassanein *et al.* 2009 and Abd-El Hamid 2009). Furthermore, auxin increased fruit quality (Barth *et al.,* 2006). Thirdly, ascorbic acid mitigates the adverse effects on plant growth by enhancing proline accumulation (Azzedine, *et al.,* 2011). The proposed function of the accumulated proline is osmosis regulation which is an adaptive mechanism to environmental stress (Aspinall and Paleg 1981). So that the increase in proline leads to enhanced leaf chlorophyll content and that reflected in more carbohydrate production through photosynthesis process and consequently improved fruit quality.

Table 12: Effect of application dates of foliar sprays, boron and ascorbic acid rates as well as their interactions on kernel length of almond trees (2022 and 2023 seasons).

Foliar sprays	Kernel length (cm)					
	2022			2023		
	Application date of foliar spray			Application date of foliar spray		
	15th September	15th December	Mean	15th September	15th December	Mean
Control	2.02 g	2.04 g	**2.03 E**	2.00 h	1.98 h	**1.99 E**
150 ppm Boron (B)	2.40 bc	2.25 ef	**2.32 C**	2.37 c	2.24 ef	**2.30 C**
300 ppm Boron	2.44 ab	2.35 cd	**2.39 B**	2.45 ab	2.27 de	**2.36 B**
750 ppm Ascorbic acid (AsA)	2.20 f	2.26 ef	**2.23 D**	2.19 g	2.30 d	**2.24 D**
1000 ppm Ascorbic acid	2.28 de	2.31 cd	**2.29 C**	2.23 f	2.34 c	**2.29 C**
300 ppm (B) + 1000 ppm (AsA)	2.47 a	2.43 ab	**2.45 A**	2.47 a	2.41 b	**2.44 A**
Mean	**2.30 A**	**2.27 A**		**2.28 A**	**2.26 B**	

Means followed by the same letter (s) within each row, column or interaction are not significantly different at 5% level

Table 13: Effect of application dates of foliar sprays, boron and ascorbic acid rates as well as their interactions on kernel width of almond trees (2022 and 2023 seasons).

Foliar sprays	Kernel width (cm)					
	2022			2023		
	Application date of foliar spray			Application date of foliar spray		
	15th September	15th December	Mean	15th September	15th December	Mean
Control	1.07 f	1.05 f	**1.07 D**	1.05 h	1.00 i	**1.02 E**
150 ppm Boron (B)	1.31 bcd	1.24 e	**1.27 C**	1.38 bc	1.28 f	**1.33 B**
300 ppm Boron	1.36 ab	1.28 de	**1.32 AB**	1.40 ab	1.30 ef	**1.35 B**
750 ppm Ascorbic acid (AsA)	1.24 e	1.29 cde	**1.27 C**	1.24 g	1.33 de	**1.28 D**
1000 ppm Ascorbic acid	1.27 de	1.31 bcd	**1.29 BC**	1.26 fg	1.35 cd	**1.30 C**
300 ppm (B) + 1000 ppm (AsA)	1.37 a	1.34 abc	**1.35 A**	1.42 a	1.39 ab	**1.40 A**
Mean	**1.27 A**	**1.25 A**		**1.29 A**	**1.27 A**	

Means followed by the same letter (s) within each row, column or interaction are not significantly different at 5% level

In addition, the obtained results regarding the effect of application dates of foliar sprays on fruit quality go in line with the findings of Agnes *et al.* (1997) on almond.

Conclusively, the interaction between all tested foliar sprays combined with application dates of foliar sprays mentioned that 300 ppm boric acid plus 1000 ppm ascorbic acid foliar spray on 15th September (the first date) induced the highest positive effect on the studied fruiting and fruit quality traits of "Umm al-Fahm" almond trees budded on bitter almond rootstock.

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