EFFECTS OF FOLIAR APPLICATION OF AMINOPLASMAL, BORON, ZINC AND THEIR INTERACTIONS ON FRUIT SET AND YIELD CHARACTERISTICS OF PISTACHIO (*Pistacia vera* L) cv. HALABY

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ABSTRACT

This study was performed at a private orchard in the Ekmale area of Duhok Governorate, Kurdistan Region, Iraq, during the seasons of 2016 and 2017 to investigate the effects of foliar sprays of three concentrations of aminoplasmal (0, 100, 200 ml.L^{-1}), three concentrations of boron (0, 200, 300 mg. L^{-1}) and three concentrations of zinc (0, 400, 600 mg. L^{-1}) on fruit set and yield characteristics of 14-years old "Halaby" pistachio. The factorial experiment within randomized complete block design was used. Foliar spraying of studied elements was applied at twice during growing seasons. The results showed that fruit set percentage, yield, and yield characteristics were significantly affected by foliar application of aminoplasmal, Boron and Zinc each alone. In combination, the triple interactions among 200ml.L^{-1} aminoplasmal plus 300mg.L^{-1} boron and 600mg.L^{-1} zinc was the most affected one which surpassed significantly on the control treatment and other treatments at both seasons. This data also display that primary fruit set% and final fruit set% in 2016 were higher than that of 2017, but yield, carbohydrate % and fat % were greater in the 2017 than they were in the 2016. In general, in this study, it was discovered that treatments with aminoplasmal, boron and zinc significantly increased yield of pistachio.

Keywords: elements, fertilizer, fat, carbohydrate, amino acids
***Part of ph.D. Dissertation of 1st author.**

تاثير الرش الورقي بالامينوبلازمال و البورن و الزنك و التداخل بينهما على نسبة العقد في الثمار و صفات الحاصل للفستق (*Pistacia vera* L) صنف حلبي

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المستخلص

اجريت الدراسة في بستان فستق اهلية تقع في منطقة ئيك–مالة، محافظة دهوك،اقليم كردستان، العراق، خلال موسمي النمو 2016 – 2017 لدراسة تاثير ثلاث تراكيز من الامينوبلازمال (صفر، 100و200مل.لتر$^{-1}$)و ثلاث تراكيز من البورون(صفر، 200و 300ملغم.لتر$^{-1}$) و ثلاث تراكيز من الزنك (صفر، 400 و 600ملغم.لتر$^{-1}$) و التداخل بينهما على نسبة العقد في الثمار و صفات الحاصل للفستق (صنف حلبي) بعمر 14 سنة. صممت التجربة حسب تصميم القطاعات العشوائية الكاملة و تم رش الاشجار بالعناصر المدروسة مرتين خلال موسم النمو. بينت النتائج ان نسبة العقد في الثمار و الحاصل و صفات الحاصل تاثرت معنويا باضافة الامينوبلازمال و البورن و الزنك كل لوحده. كذلك اوضحت النتائج ان التداخل بين 200مل.لتر$^{-1}$ امينوبلازمال و 300ملغم.لتر$^{-1}$ بورون و 600 ملغم.لتر$^{-1}$ زنك كانت الاكثر تاثيرا و التى تفوقت معنويا على المعاملات الاخرى. بينت النتائج ان نسبة العقد المبكر و النهائي للثمار في سنة الحمل الخفيف 2016 (OFF year) كانت اكثر منها في سنة الحمل الغزير 2017 (ON year) و لكن الحاصل و نسبة الكاربوهيدرات و الدهون كانت اكثر في سنة الحمل الغزيرعما عليه في سنة الحمل الخفيف. بينت الدراسة ان المعاملة بالامينوبلازمال و البورن و الزنك خاصة بالتراكيز العالية ادى الى زيادة معنوية في حاصل الفستق.

الكلمات المفتاحية: فستق، نسبة العقد، الحاصل، الكاربوهيدرات، الاحماض الامينيه، الدهون
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INTRODUCTION

Pistachio (*Pistacia vera* L.), is an important horticulture crop, which has highest economic value, Pistachio kernel is rich with fat, fatty acids and elements such as calcium, magnesium, potassium and vitamins like B2, B1 B, A and B6 (12). Fruit dropping in pistachio orchards is one of the numerous problems which country's orchard men face with it. Environmental stresses and inadequate nutrition during flowering time have increased these problems in recent years, On the other hand reduction of water increased salinity and unfavorable environmental conditions in most pistachio orchards, and especially during flowering time has reduced fruit set (13). Amino acids is a well-known biostimulant which has positive effects on plant growth and yield. (21). In another experiment, it has been shown that amino acids can increase yield in 'Mumtaz' and 'Fandoghi' pistachio, because plants are able to use amino acids as a nitrogen source (7). Also, Kamiab *et al*., (18) was noted that foliar application of amino acid (3g/L) on two pistachio cultivars improved yield in comparison with control. Boron is an essential element for plants. It has significant roles in different metabolic functions that may also impact tree yield and fruit quality (22). Boron deficiency is one of the most common worldwide plant microelement deficiencies (29). Boron, causing pollen germination and pollen tube growth and have many roles in metabolic activities. Encouraging results have been obtained in avocadoes, prunes, and pears (24). In pistachio, boron plays an important role in flowering and fruit set (8). Zinc is an important element for plant nutrition. It has both a functional role and a structure role in reactions involving enzyme activity (22). Soil in which pistachio is grown is characterized by high pH carbonate content and low organic matter. In these soils, deficiency of Zn and other element become sever (35). One of the reasons of low fruit set could be the deficiency of zinc and some other elements; it may bet possible that foliar applications of Zn could be a solution of this problem (15). Fruit set is an important component of yield (30). Soliemanzadeh, A., *et al*., (34) Indicated that foliar application of Zn on pistachio trees cv. Owhadi significantly increased primary fruit set, final fruit set, yield and yield component in comparison with control. Baybordi and Malakouti (10) Stated foliar application of Zn increased the final fruit set of pistachio trees. Zn-deficiency leads to the number of nuts per cluster dramatically reduced and most of them can be blanks (8). The aim of this study was to determine the effect of foliar application of aminoplasmal, zinc and boron on fruit set, yield and yield component of "Halaby" pistachio in two study seasons.

MATERIALS AND METHODS

This study was carried out at a private orchard in the Ekmale area of Duhok governorate, Kurdistan Region, Iraq. The trees under taken in this study were 14-years Old pistachio (*Pistacia vera.* L) cv. Halaby and grown under rainfed conditions. The trees were similar as it is possible in growth vigor, size and bloom density. The trees were spaced in rows 4 m apart and at distances of 3m a long each row, regular agricultural practices were applied to all trees throughout this study.In this study, the commercial product ''Aminoplasmal'' was used as a source of amino acids, which was supplied from Aminoplasmal B. Braun 10% (B. Braun Melsungen AG), at three concentrations (0, 100 and 200 $ml.L^{-1}$), boron was supplied from Boric acid at three concentrations (0, 200, and 300 $mg.L^{-1}$) and Zinc was supplied from Zinc sulfate at three concentrations (0, 400, and 600 $mg.L^{-1}$). All treatments were applied at the time of swollen bud and repeated one month later on (23^{th} of March and 27^{th} of April) respectively, in two consecutive seasons 2016 (OFF) and 2017 (ON) years. Trees were hand sprayed to the point of runoff with treatments and Tween-20 was used as a wetting agent. Treatments were consisted of 81 trees with three replicates and each replicate was contained 27 trees, the factorial experiment within randomized complete block design (RCBD) was used. All data were statistically analyzed with computer using SAS program (31). The differences between various treatment means were tested with Duncan Multiple Range test at 5% level. For fruit set, four branches (from different direction of each tree) were randomly selected for each treatment. Flowers on the labeled shoots were counted at the (middle of April). For the

primary fruit set%, fruit on the shoots were counted at the time of post-bloom (early of May), and fruit set percentage was calculated according to the following equation:

Primary fruit set (%) = [No. of fruit (post bloom) / Total no. of flower] × 100

Also final fruit set% was estimated by dividing the number of fruit determined after harvesting by the total number of flowers:

Final fruit set (%) = [No. of fruit (end of September) / Total no. of flower] × 100

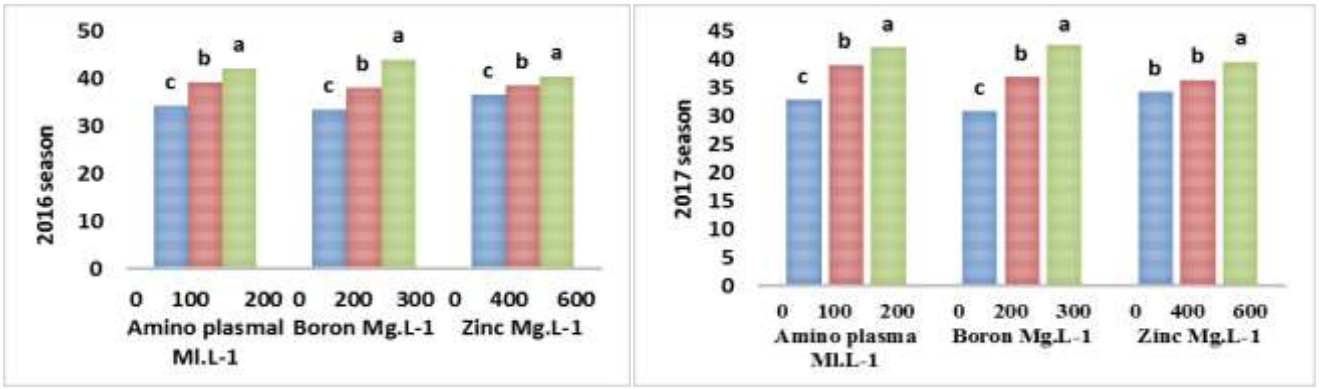
For yield and yield component, all pistachio clusters were removed from the labeled branches of the tree by hand, when the fruit reached the stage of physiological maturity, signaled by a reddish hull, fresh yield per shoot for each treatment was determined by means of weighing clusters. In addition, the samples were transferred to the laboratory in order to measure and calculate the fat, and carbohydrate percentage. For calculate the fat%, it was estimated by using Soxhlet method according to A.O. A. C. (1), carbohydrate% was estimated by using spectrophotometer Pharmacia LKB at (480nm), (16).

RESULTS AND DISCUSSION

1-Primary fruit set%

The obtained results of both study seasons in Fig.1, reveals that both aminoplasmal and boron at high concentrations, (200 ml .L−1) aminoplasmal, 300 mg. L−1 boron significantly increased primary fruit set, as compared to the control. Whereas the application of zinc at 600 mg. L−1 concentration in first season significantly increased primary fruit set in comparison with control, and 400 mg. L−1 zinc and with control trees in second season.

Figure 1. Effect of Aminoplasmal, Boron and Zinc on primary fruit set%



(Columns with the same letters are not significantly different according to Duncan's multiple range tests at 5% level)

Data reported in Table1. shows that the interaction among 200 ml.L^{-1} aminoplasmal, 300 mg.L^{-1} Boron and 600 mg.L-^{1} Zinc gave the highest value in both season, in this concern, the lowest number of fruits was obtained with interaction of 0 mg.L^{-1} aminoplasmal x 0 mg.L^{-1} Boron and 0 mg.L-^{1} Zinc.

Table 1. Effects of foliar spray of Aminoplasmal, Boron, Zinc and their interactions on primary fruit set% **of pistachio cv. Halaby in (2016, 2017) seasons**

Amino plasmal ml.L^{-1}	Boron mg.L^{-1}	2016 Zinc mg.L^{-1}			2017 Zinc mg.L^{-1}		
		0	400	600	0	400	600
0	0	28.51j	31.43ij	31.74ij	19.77h	28.06g	28.97g
	200	33.08g-j	35.50f-i	35.97f-i	32.90e-g	33.70d-g	34.81c-g
	300	37.03e-h	37.43e-h	38.26ef	36.08c-g	38.75b-f	43.10a-c
100	0	31.84ij	35.86f-i	35.95f-i	28.30g	30.67fg	34.07d-g
	200	36.28e-i	37.44e-h	41.04de	36.43b-g	36.45b-g	39.15b-f
	300	44.05cd	44.34b-d	46.04bc	40.95a-e	41.81a-d	44.92ab
200	0	32.84h-j	36.27e-i	37.05e-h	36.00c-g	36.66b-g	37.78b-f
	200	37.87e-g	39.30ef	47.19bc	39.28b-f	39.51b-e	40.11a-e
	300	48.50bc	49.00b	54.22a	41.89a-d	42.29a-d	48.32a

Means within a column, row and their interactions followed with the same letters are not significantly different from each other according to Duncan's multiple range tests at 5% level

2-Final fruit set%

The results obtained from first and second seasons illustrates that final fruit set% were increased with the increasing the levels of aminoplasmal up to 200 ml .L^{-1} and boron up to 300 mg.L^{-1} concentrations. On the other hand there are a significant difference between the levels of aminoplasmal and boron in both seasons. Whereas, highest final fruit set was obtained at both concentration of Zinc at 400 and 600 mg.L^{-1} as compared to untreated trees in 2016, while in 2017 seasons, foliar application of 600 mg.L^{-1} Zinc was significantly surpassed in enhancing final fruit set% in comparison with other concentration and untreated trees.

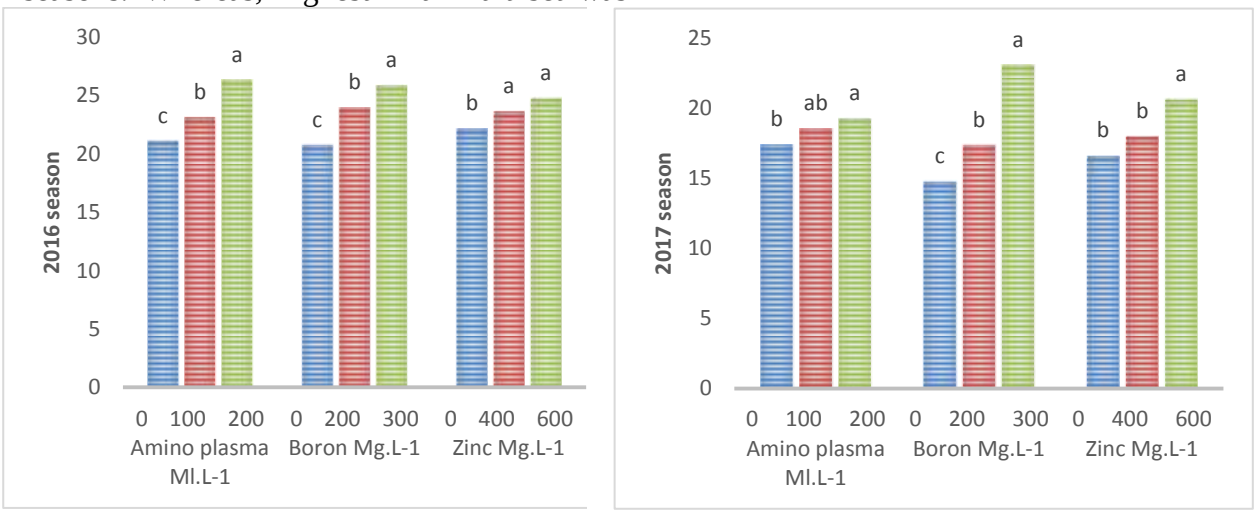


Figure 2. Effect of Aminoplasmal, Boron and Zinc on final fruit set%

(Columns with the same letters are not significantly different according to Duncan's multiple range tests at 5% level) In respect with the interaction of the three studied factors, (Table2) the third level of aminoplasmal .L^{-1}, Boron and Zinc at both study seasons gave the highest significant final fruit set (30.65%) in first season and (28.62%) at the second season, while the lowest value (17.69%) and (11.77%) was obtained from untreated trees (control trees) respectively.

Table 2. Effects of foliar spray of Aminoplasmal, Boron, Zinc and their interactions on final fruit set% **of pistachio cv. Halaby in (2016, 2017) seasons.**

Amino plasmal ml.L^{-1}	Boron mg.L^{-1}	2016			2017		
		Zinc mg.L^{-1}					
		0	400	600	0	400	600
0	0	17.69 l	19.28 kl	20.41 i-l	11.77h	13.81gh	14.95f-h
	200	19.86 j-l	20.45 i-l	22.41 h-k	15.76e-h	16.54d-h	17.3c-g
	300	21.88 h-k	23.84 e-i	24.12 e-h	18.93c-g	19.90c-f	27.53a
100	0	18.21 l	21.96 h-k	22.30 h-k	13.58gh	14.78f-h	16.07d-h
	200	22.98 g-i	23.51 f-i	24.53 e-h	16.12d-h	18.89c-g	19.75c-f
	300	23.94 e-i	24.76 c-g	26.12 c-g	20.50b-e	21.47b-d	25.54ab
200	0	19.81 j-l	22.80 g-k	24.22 b-g	15.57e-h	16.06d-h	16.10d-h
	200	26.78 b-e	27.20 a-e	27.94 a-d	16.32d-h	17.71c-g	17.79c-g
	300	28.32 a-c	28.91 ab	30.65 a	20.79b-e	22.41bc	28.62a

Means within a column, row and their interactions followed with the same letters are not significantly different from each other according to Duncan's multiple range tests at 5% level

3- Yield per shoot (g)

As shown in Fig.3 all treatment significantly increased yield per shoot at both seasons**.** So increasing the levels of aminoplasmal up to (200ml.L^{-1}), Boron to (300ml.L^{-1}), and Zinc to (600ml.L^{-1}) lead to significant increase in yield of pistachio at first and second study seasons.

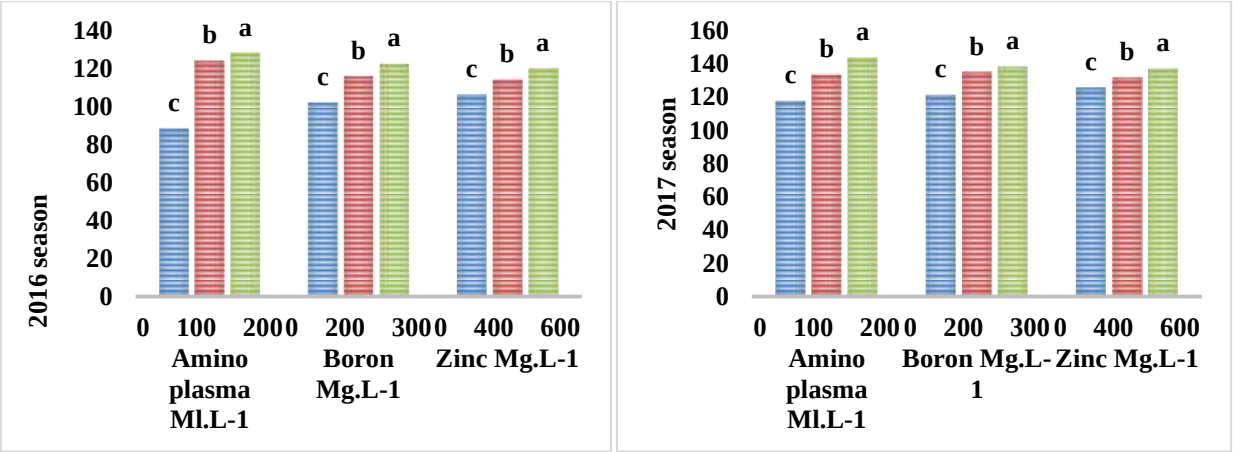


Figure 3. Effect of Aminoplasmal, Boron and Zinc on yield/shoot (g)

(Columns with the same letters are not significantly different according to Duncan's multiple range tests at 5% level)

In this research (Table 3), during 2016 (OFF year) the maximum yield of 140.42g was obtained from the interactions between the three studied treatment at concentration 200 ml.L^{-1} aminoplasmal x 300 mg.L^{-1} Boron and 600 mg.L-1 Zinc, While the lowest yield was found with the untreated trees (57.61g). on the other hand, during 2017 (ON year), in respect with the interactions of the three studied factors, the maximum value was (158.52g) at the interactions of third level of each treatment, where as the minimum value was revealed (74.33g) with untreated trees.

Table 3 effects of foliar spray of Aminoplasmal, Boron, Zinc and their interactions on yield/shoot (g) **of pistachio cv. Halaby in (2016, 2017) seasons**

Amino plasmal ml.L^{-1}	Boron mg.L^{-1}	2016			2017		
		Zinc mg.L^{-1}					
		0	400	600	0	400	600
0	0	57.61 n	71.89 m	77.20 m	74.33 m	99.51 l	119.28 jk
	200	90.89 l	95.62 kl	97.59 kl	122.50 jk	127.53 h-k	128.44 g-j
	300	93.71 kl	100.34 jk	111.08 hi	126.43 i-k	129.41 f-j	131.92 f-i
100	0	108.60 ij	111.17 hi	120.79 e-g	127.45 h-k	131.38 f-j	132.58 e-i
	200	120.97 e-g	125.20 d-f	132.59 a-d	128.59 g-j	133.46 e-i	136.56 c-h
	300	125.58 d-f	134.58 a-c	135.67 ab	130.67 f-j	136.97 c-g	141.20 b-e
200	0	114.13 g-i	125.56 d-f	131.11 b-d	133.78 e-i	136.13 d-h	138.02 c-f
	200	118.80 f-h	128.02 b-e	133.43 a-d	143.43 b-d	144.59 b-d	148.40 b
	300	126.59 c-f	134.40 a-c	140.42 a	144.09 b-d	145.57 bc	158.52 a

Means within a column, row and their interactions followed with the same letters are not significantly different from each other according to Duncan's multiple range tests at 5% level

4- Carbohydrate %

According to the Fig.4 results determined that the treatments in this study, termed of Carbohydrate% had a significant differences. The results of the first and second seasons revealed that spraying pistachio trees with 200 mg.L^{-1} aminoplasmal resulted in a significant increase in Carbohydrate content% in comparison with control. In addition at both study seasons, significant differences were obtained in Carbohydrate% as a result of foliar application of Boron concentrations at 200 mg.L^{-1} and 300 mg.L^{-1} Boron. However concerning the application with zinc, in 2016 year, Zinc application at 600 mg.L^{-1} increased evaluations of Carbohydrate% compared with 400 mg.L^{-1} Zinc and control. Beside in 2017 growing season, Zinc application increased the Carbohydrate% at the second and third concentration of Zn compared with the control.

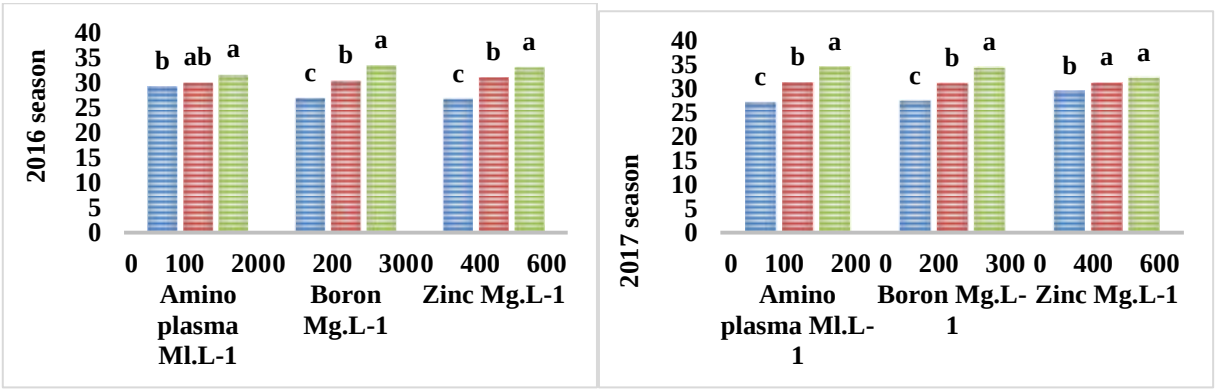


Figure 4. Effect of Aminoplasmal, Boron and Zinc on Carbohydrate%

(Columns with the same letters are not significantly different according to Duncan's multiple range tests at 5% level).

Referring to the triple interactions, the highest carbohydrate (36.02), (38.38%) in OFF and ON year respectively, was obtained from the interactions of aminoplasmal (200ml.L^{-1}) plus boron (300mg.L^{-1}) and zinc (600mg.L^{-1}) compare with control that record lowest value (19.05) and (21.68%). (table 4)

Table 4. Effects of foliar spray of Aminoplasmal, Boron, Zinc and their interactions on carbohydrate% of pistachio cv. Halaby in (2016, 2017) seasons

Amino plasmal ml.L^{-1}	Boron mg.L^{-1}	2016			2017		
		Zinc mg.L^{-1}					
		0	400	600	0	400	600
0	0	19.05i	25.68gh	27.41a-c	21.68j	24.07ij	22.02ij
	200	26.85e-h	30.22c-g	32.74a-d	23.59ij	26.50hi	29.43e-h
	300	31.11a-f	33.93a-c	35.37ab	30.34e-h	32.14c-g	34.14a-e
100	0	23.08hi	27.76d-h	30.28c-g	26.46hi	28.89f-h	30.27e-h
	200	26.46f-h	30.41b-g	32.88a-c	31.24c-h	32.07c-g	32.10c-g
	300	30.29c-g	34.29a-c	34.58a-c	32.74b-g	33.21b-g	34.28a-e
200	0	25.52gh	30.34c-g	32.77e-h	28.74gh	30.78d-h	33.22b-g
	200	27.48e-h	31.65a-e	34.76a-c	33.93a-f	35.64a-d	35.68a-d
	300	30.26c-g	34.77a-c	36.02a	36.19a-c	37.41ab	38.38a

Means within a column, row and their interactions followed with the same letters are not significantly different from each other according to Duncan's multiple range tests at 5% level

5- Fat %: According to Fig 5 results revealed that in 2016 first season both aminoplasmal and Zinc at 200ml.L^{-1} aminoplasmal and 200mg.L^{-1} zinc gave the significant increase on fat% in comparison with control, on the other hand boron application at 300mg.L^{-1} increased fat % in comparison with 200mg.L^{-1} and with control. In 2017 growing season, obtained results in this study according to Fig.5 showed that, there were no significant differences among the means of fat% of application aminoplasmal and Boron at second and third levels in comparison with control; however there were no significant effect of Zinc application on %.

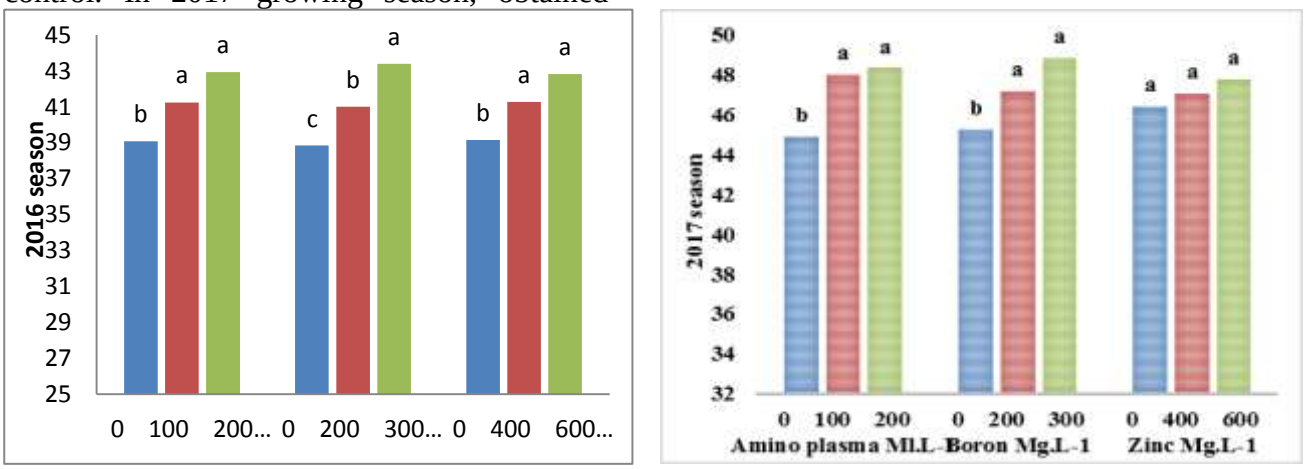


Figure 5. Effect of Aminoplasmal, Boron and Zinc on Fat content %

(Columns with the same letters are not significantly different according to Duncan's multiple range tests at 5% level)

Results in Table5 show the various treatments in terms of effects on fat%, during OFF and ON years, there were significant differences, so the greatest effect in fat% from the triple interaction value (46.56%); (50.24%), respectively was obtained from interactions of 200mg.L^{-1} amino plasmal +300 mg.L^{-1} Boron +600 mg.L-Zinc at both seasons. However, the control treatments have the least effects (34.57%); (39.87%) respectively.

Table 5. Effects of foliar spray of Aminoplasmal, Boron, Zinc and their interactions on Fat content % of pistachio cv. Halaby in (2016, 2017) seasons

Amino plasma ml.L^{-1}	Boron mg.L^{-1}	2016			2017		
		Zinc mg.L^{-1}					
		0	400	600	0	400	600
0	0	34.57 h	37.73e-h	38.70d-h	39.87d	41.54cd	42.95b-d
	200	35.20gh	38.47d-h	40.67b-f	44.62a-d	45.38a-d	45.71a-c
	300	40.40b-g	42.37a-e	43.54a-d	47.28a-c	47.65ab	48.92ab
100	0	36.59f-h	40.20c-g	40.43b-g	46.62a-c	47.28a-c	48.16ab
	200	40.27c-g	40.57b-f	43.37a-d	46.98a-c	47.79ab	48.32ab
	300	40.57b-f	43.47a-d	45.73ab	48.86ab	49.08ab	49.12ab
200	0	38.80d-g	40.47b-g	42.08a-e	46.29a-c	46.95a-c	47.55a-c
	200	42.43a-e	43.77a-d	44.33a-c	47.96ab	48.76ab	49.00ab
	300	43.50a-d	44.43a-c	46.56a	49.05ab	49.12ab	50.24a

Means within a column, row and their interactions followed with the same letters are not significantly different from each other according to Duncan's multiple range tests at 5% level

It is observe from the above mentioned results that a significant increases obtained in the tree yield and its components by foliar application of Aminoplasmal at both season especially at the second season, this may be due to the role of Aminoplasmal behold as precursor and constituents of the proteins (25), which are important for stimulation of cell growth. They include both acid and basic groups and work as a buffers, which aid to maintain favorable or indirectly influence the physiological activities in plant growth and development such as exogenous application of amino acids have been reported to modulate the growth (29). On the other hand, the application of amino acids increase the production of carbohydrate and assimilation in to the plants, and as a result, the growth of kernel increases (9). The present results are in agreement with the finding obtained by (3, 6, 7, 23, 27). From boron application, it was observed that Boron foliar application significantly increased primary fruit set%, final fruit set%, yield characteristic, during OFF and ON years, respectively. Microelements such as B and Zn are essential for different biological functions that may be responsible for tree yield and fru of increased pollen tube germination due it quality (30, 3). The results are in conformity, with (2, 4, 14, 19, 20, 25, 26, 36, 37). Application of Zinc improved all the studied traits during OFF and ON years, due to the role of Zinc played an important role in biosynthesis and movement of natural auxins, namely that of IAA to the fruit pedicels. It seems that an improvement in percentage of fruit set could be explained as a result to Zn treatment (19).The present results are in agreement with the finding obtained by Soliemanzadeh, A., *et al*., 2013 (31), they reported increasing fruit set percentage and yield characteristic by foliar spray with Zn, perhaps these increases in yield were due to significant increase in leaf Zn concentrations, which in turn induce more flowering and minimize fruit let drop in pistachio trees. Jumaa and Ali, (2016) (17) studied the effect of foliar application of potassium zinc and gibberelic acid on yield and some fruit quality of pomegranate cv. Salimy. The results showed zinc as the sprayed concentration of 1000 mg.L-1 achieved significant increase in fruit yield, fruit weight.

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