EFFECT OF FOLIAR APPLICATION OF ZINK AND SALICYLIC ACID ON VEGETATIVE GROWTH AND YIELD CHARACTERISTICS OF HALAWANI GRAPE CULTIVAR (*Vitis vinifera* L.)

Sh. M. M. Al-Atrushy

Prof.

Dep. of Hort. Coll. of Agricultural engineering sciences, University of Duhok, Iraq

shawkat.mustaf@uod.ac

ABSTRACT

THis investigation aimed to study the effect of foliar application with zinc alone or in combination with salicylic acid on vegetative growth, yield, physical and chemical properties of Halawani grapevine cultivar during two successive seasons (2017 and 2018). Zinc was used at concentration of 2 and 4 $g.L^{-1}$ in a chelated form and salicylic acid at concentration of (50, 100 and 150 mg. L^{-1}) in addition to control treatment for each of them. The result obtained proved that all parameters such as leaf area, total chlorophyll, number and weight of cluster, yield, berries size and weight, as soon as TSS, total sugar, juice percentage and density, β-carotenes, Zn, N. proline content of leaves were increased significantly as compared with control, while total acidity and total phenols were decreased by all treatments as compared with control. Furthermore, combination between high concentration of zinc and salicylic acid improved all parameters in comparison with the control.

Keyword: Zink, salicylic acid, grape, Halawani, quality.

تاثير الرش الورقي بالزنك وحامض السالساليك في النمو الخضري وصفات الحاصل لصنف العنب حلواني (*Vitis vinifera* L.)

شوكت مصطفى محمد الاتروشي

استاذ

قسم البستنة/ كلية علوم الهندسة الزراعية/جامعة دهوك

المستخلص

تهدف هذه التجربة الى دراسة تاثير الرش بالزنك لوحده او بالتداخل مع حامض الساساليك على صفات النمو الخضري وصفات الحاصل الفيزياوية والكيمياوية لصنف العنب الحلواني خلال موسمي النمو (2017-2018). استعمل الزنك بتركيز (2 و 4 غم.لتر$^{-1}$) بصورته المخلبية وحامض السالساليك بتركيز (50 ، 100 و150 ملغ.لتر$^{-1}$) بالاضافة الى معاملة المقارنة لكل منهم. اظهرت النتائج ان جميع الصفات مثل مساحة الورقة والكلوروفيل الكلي وعدد ووزن العناقيد والحاصل ووزن وحجم الحبات وكذلك انسبة المئوية للمواد الصلبة الذائبة والسكريات الكلية ونسبة وكثافة العصير زادت معنويا مقارنة بمعاملة المقارنة، بينما النسبة المئوية للحموضة الكلية والفينولات الكلية انخفضت معنويا مقارنة بمعاملة المقارنة. علاوة على ذلك فان التداخل بين التركيز العالى للزنك وحامض السالساليك حسنت جميع الصفات مقارنة بمعاملة المقارنة.

كلمات مفتاحية : صفات الحاصل الفيزياوية والكيميائية , مساحو الورقة , الكلوروفيل , وزن الغنقود

Received:13/7/2020, Accepted:11/10/2020

INTRODUCTION

For more than six thousand years, Humans have been concerned with growing grapes, producing and processing fruit and juice (7). Commercial grapes belonging to the genus Vitis which is one of the 14 genuses belonging to the Vitaceae family (3,16). Grape cultivation has started first in Central Asia in the area between the south of the Black Sea and the Caspian Sea, this region was agreed upon by most botanists as the origin of European grapes (*Vitis vinifera* L). Therefore, the best areas for grapevine cultivation was located between two latitudes (34-45) north and (31-38) south (3 , 15). According to the World Viticulture Situation (24); 7.5 million ha is the global area under vines in 2016 producing over 75.8 million tons of grapes. For the medicinal value of grapes, it is a nutritional substance used as a stimulant for brain cells, heart muscles, tonic for the liver and kidneys and reduces the incidence of diseases of the stomach, intestine and urinary system (15). Increasing yield and improving quality of grape is dependent on different practices (18). There are many factors effect in the quantity and quality of grape such as pruning, crop load balance, thinning, girdling, topping and tipping, the use of plant growth regulators and correct nutrition (27). Zinc is one of the essential elements for plants (8). Zn is required for the synthesis of auxins, chlorophyll and starch and carbohydrate metabolism (2, 19). Grapevines require approximately 0.5 kg Zn/ha/year (17). Zinc deficiency is characterized by abnormal development of internodes (‘zig-zag’ growth pattern of shoots), interveinal chlorosis in early summer and small leaves (3 , 10), production of clusters with und veloped shot berries and generally poor fruit set (2 , 25). Nikkhah (29) found that using Zink fertilization (2g. L^{-1}) on seven cultivars of grapes significantly increased berry (number, length and weight), cluster (length and weight) characteristics and TSS. Salicylic acid and its derivatives is one of the plant hormones produced by the plant, naturally belongs to the group of phenolic acids and consists of a ring linked to the group of hydroxyl and carboxyl group and the starting constituent to form is the cinnamic acid (13). It is mainly manufactured within the plant in cytoplasmic cell, this acid was first discovered in *Salix* spp., which contains the salicin compound by 9.5–11% and is present in the plant in the form of free phenolic acids or associated with amino compounds (13). Abdle-Salam (1) showed foliar application of salicylic acid at 100 and 150 mg. L^{-1} on Bez El Naka grape cultivar significantly improved cluster weight, juice volume, total chlorophyll N.P.K. content of leaves, TSS, acidity, total phenols and b-carotene compared with control. So, this study aimed to investigate the physical and chemical properties of this cultivar in response to foliar sprays of Zink alone or combined with Salicylic acid to improve its quality, transportation and marketing tolerance.

MATERIALS AND METHODS

This research was carried out in a private vineyard located in bare-bhar village, Zawita town, Duhok province, Kurdistan region, Iraq, during two growing seasons of 2017-2018 to study the effect the spraying Zink with three concentrations (0, 2 and 4 g.L^{-1}) in a chelated form and salicylic acid (SA) with four concentrations (0, 50, 100 and 150 mg. L^{-1}), on vegetative growth yield, physical and chemical properties of Halawani grape variety. All treatments were sprayed twice per season, the first one was two weeks before full bloom and the second was carried out 5 weeks later of the first spraying. Healthy vines which were 12-years old and nearly uniform in growth vigor were selected and marked. Vines planted at 2 x 2.5 meters apart and trained as ‘T’ trails system. All vines were pruned at mid of March by leaving 7 fruit canes, of 10 buds with 7 renewals spur each with 2 buds. Vines were irrigated with drip irrigation system. The experiment was arranged in a randomized complete block design with one individual vine for each experimenttal unit and replicated three times. All vines received the standard agricultural practices used in the vineyard including fertilizer application, irrigation and diseases and pests control except for the tested different treatments through the two studied seasons. Tween-20, as a wetting agent at 0.1% was added to all spraying solutions of Zink and SA, spraying carried out till runoff. All the results were analyzed statistically by using

SAS programs (31). Duncan‘s multiple range test (DMRT) at 5% level of portability was used to compare the treatments means according to the Al-Rawi, and Khalafalla (5.) Potential effects of the spraying Zink and Salicylic acid were evaluated in terms of the change in leaf area, chlorophyll, number of clusters, cluster ‘s weight and yield.Vine^{-1}, as well as physical (weight and size of 100 berries) and chemical parameters (TSS, total sugar, total acidity, anthocyanin, proline and β-carotene) and N. Z content in petiole. Chlorophyll content was determined using a SPAD-502-meter (Minolta Camera Co., Osaka, Japan). Then it was converted to µg.m$^{2-1}$ according to Pestana *et al.* (25). Y=0.15X^2+1.49+85 (Y total chlorophyll µmol.m^{-1}, X = SPAD reading).

RESULTS AND DISCUSSION

1-Vegetative growth characteristics: Data in table (1) shows that leaf area and total chlorophyll were increased significantly with increasing Zink and Salicylic acid for both season, highest values of leaf area and total chlorophyll (177.01; 166.16 cm^2 and 186.98; 187.65 µg.m$^{2-1}$) respectively were obtained with foliar application of high concentration of Zink, also spraying of high concentration of SA gave the highest values of leaf area and total chlorophyll (175.19; 164.43cm^2 and184.66; 188.48 µg.m$^{2-1}$) respectively for both season. Same table also shows the interaction between foliar application of Zink and Salicylic acid, best values of leaf area were resulted from the interaction between the foliar application of 4g.L^{-1} Zn + 150 mg.L^{-1} SA in the first season and 4g.L^{-1} Zn + 100 mg.L^{-1} SA on the second season.

Table 1. Effect of foliar sprays of Zink and Salicylic acid on some vegetative characteristics of grapevine cv. Halawni

			Leaf area (cm2)		Total chlorophyll (µg.m$^{2-1}$)	
			2017	2018	2017	2018
Zink (g.L^{-1})		0	154.09 c	146.38 c	159.93 b	160.06 b
		2	168.14 b	158.74 b	165.52 b	173.97 b
		4	177.01 a	166.16 a	186.98 a	187.65 a
Salicylic acid (SA) (mg.L^{-1})		0	155.97 c	148.17 c	159.49 c	160.98 b
		50	164.01 b	155.81 b	166.38 bc	166.18 b
		100	170.49 a	160.86 ab	172.71 b	179.93 a
		150	175.19 a	164.43 a	184.66 a	188.48 a
Zink (0)	SA	0	140.17 g	133.17 g	146.27 f	147.50 f
		50	153.17 f	145.52 f	155.76 ef	157.17 de
		100	158.52 ef	150.59 def	167.57 cde	163.76 cde
		150	164.48 def	156.26 c-f	170.13 b-e	171.83 bcd
Zink (2g.L^{-1})	SA	0	156.83 ef	148.98 ef	156.37 def	157.80 de
		50	165.66 cde	157.38 b-e	157.41 def	158.86 de
		100	173.51a-d	161.50 a-d	161.37 def	184.77 abc
		150	176.58 abc	167.75 abc	186.94 ab	194.45 a
Zink (4g.L^{-1})	SA	0	170.92 bcd	162.37 abc	175.84 bcd	177.65 a-d
		50	173.20 a-d	164.54 abc	185.96 abc	182.51 abc
		100	179.44ab	170.46 a	189.19 ab	191.27 ab
		150	184.51 a	168.62 ab	196.92 a	199.16 a

Mean in each column followed by the same letters are not significantly different at P≤ 0.05 according to Duncan’s multiple range test.

whereas the best values of total chlorophyll were resulted from the interaction of 4g.L^{-1} Zn + 150 mg.L^{-1} SA in the both season.

2-Yield and its components: It's clear from Table (2) that numbers of clusters per vine were increased significantly as foliar application of Zink was increased. It is tangible that treatment of 4 g. L^{-1} gave the highest number of clusters per vine; it recorded 47.11 and 43.16 clusters for the both seasons, respectively compare to the control which gave a lower significantly number of cluster (33.85 and 28.55) in both seasons, respectively. Also the table 2 shows that cluster’s weight were increased significantly by increasing concentration of Zink, since the highest weight of cluster (811.89 and 956.54 g) for the both seasons, respectively was obtained by application of 4g. L^{-1} compared to the lowest weight of cluster (792.11 and 831.72 g) for the two seasons, respectively was obtained by the control .From the same table, the yield per vine was significantly increased by increasing Zink concentration. Similarly, the highest yield per vine was obtained by application of 4g. L^{-1} of Zink which recorded 39.355 & 41.322 $kg.vine^{-1}$ for the both seasons, respectively. This increment in vine yield may be attributed to the increase in both numbers of clusters per vine and cluster's weight. Data of Table 2 also clearly indicate that numbers of clusters per vine, cluster weight and yield per vine were increased significantly as SA concentration was increased. It is obvious that treatment of 150 $mg.L^{-1}$ SA gave the highest number of clusters per vine, cluster weight and yield per vine (44.06 & 46.55; 910.99 & 956.54; 39.72 & 41.71) for the both seasons, respectively, except number of cluster which recorded the highest value by the foliar application of 50 $mg.L^{-1}$ compared to the lowest values obtained with control. For the interaction, table 2 shows that the interaction between foliar application of Zink and SA increased number of clusters per vine, cluster weight and yield, the highest value (56.88 & 55.18; 927.30 & 977 60; 50.17 & 52.68) respectively for both season were resulted from the interaction of $4g.L^{-1}$ Zink + 150 $mg.L^{-1}$ SA, except number of cluster which recorded the highest value by the foliar application of $4g.L^{-1}$ Zink +100 $mg.L^{-1}$ SA, while the lowest value (23.01 & 18.01; 751.49 & 760.76; 11.87 & 12.46) of number of clusters, cluster's weight and yield per vine for both season respectively, were obtained from the control.

Table2. Effect of foliar sprays of Zink and Salicylic acid on Yield and its components characteristics of grape cv. Halawni

Treatments			Characteristics					
			No. of clusters		Cluster weight. (g)		yield ($Kg.vine^{-1}$)	
			2017	2018	2017	2018	2017	2018
Zink ($g.L^{-1}$)		0	33.85 c	28.55 c	792.11 b	831.72 b	22.372 c	23.491 c
		2	38.96 b	34.46b	846.85 b	889.20 b	28.885 b	30.329 b
		4	47.11 a	43.16a	917.94 a	963.84 a	39.355 a	41.322 a
Salicylic acid (SA) ($mg.L^{-1}$)		0	30.76 d	24.76 c	826.85 b	868.20 b	20.353 d	21.371 d
		50	36.51 c	28.51 c	910.99 a	852.49 b	25.523 c	26.799 c
		100	44.06 b	40.06 b	859.47 ab	902.45 ab	35.207 b	36.967 b
		150	48.55 a	46.55 a	811.89 b	956.54 a	39.732 a	41.719 a
Zink (0)	SA	0	23.01 f	18.01 g	751.49 bc	760.76 c	11.875 g	12.469 g
		50	30.80 ef	22.80 fg	881.44 ab	789.07 bc	18.949 f	19.897 de
		100	39.82 cd	35.82 cd	810.99 abc	851.54 abc	28.274 de	29.688 de
		150	41.77 cd	40.77 bc	724.54 c	925.51 ab	30.391 de	31.910 de
Zink ($2g.L^{-1}$)	SA	0	30.93 ef	25.93 ef	798.02 abc	837.92 abc	19.452 f	20.425 f
		50	36.53 de	28.53cd	924.25 a	866.51 abc	24.008 ef	25.208 ef
		100	41.36 cd	39.36 bcd	839.90 abc	881.89 abc	33.447 cd	35.120 cd
		150	47.01 bc	46.21 b	825.25 abc	970.46 a	38.631 bc	40.563 bc
Zink ($4g.L^{-1}$)	SA	0	38.33 de	32.33 de	931.05 a	930.19 a	29.732 de	31.219 de
		50	42.21cd	36.21cd	927.30 a	973.66 a	33.611 cd	35.292 cd
		100	51.01 ab	47.01 b	927.54 a	973.91 a	43.900 ab	46.095 ab
		150	56.88 a	55.18 a	885.90 ab	977.60 a	50.175 a	52.684 a

Mean in each column followed by the same letters are not significantly different at P≤ 0.05 according to Duncan's multiple range test

3-Physical parameters: Table 3 clearly shows that weight and size of 100 berries and total soluble solid were increased significantly as Zink concentration was increased. It is obvious that treatment of 4g. l^{-1} gave the highest values recorded (381.82 & 420.01 g; 437.81 & 457.81 cm^3; 26.81&28.69 %) in the two seasons, respectively of weight and size of 100 berries and total soluble solid respectively, whereas, a lower significantly weight and size of 100 berries and total soluble solid (320.04 & 352.14 g; 352.04 and 363.73cm^3; 21.34 and 2225 %) in both seasons, respectively. Same table also clearly indicate that weight and size of 100 berries and total soluble solid were increased significantly as SA concentration was increased. It is obvious that treatment of 150 ***mg.L^{-1} SA*** gave the highest weight and size of 100 berries and total soluble solid (389.37 & 450.53; 428.31& 489.08; 26.21 & 28.05) for the both seasons, respectively, compared to the lowest values obtained with control.

Table 3 Effect of foliar sprays of Zink and Salicylic acid on some physical characteristics of grape cv. Halawni

Treatments			Characteristics					
			We. of 100 berries(g)		Size of 100 berries. (g)		TSS %	
			2017	2018	2017	2018	2017	2018
Zink (g.L^{-1})		0	320.04 b	352.04 b	363.73 b	383.73 b	21.34 c	22.257 c
		2	374.46 a	428.58 a	445.65 a	465.65 a	23.83 b	26.167 b
		4	381.82 a	420.01 a	437.81 a	457.81 a	26.81 a	28.690 a
Salicylic acid (SA) (mg.L^{-1})		0	321.14 b	353.25 c	365.04 c	385.04 c	21.48 c	22.213 c
		50	356.31 ab	391.94 bc	407.22 bc	427.22 bc	23.44 bc	25.971 b
		100	368.28 a	405.11 ab	421.57 ab	441.57 ab	24.84 ab	26.581 ab
		150	389.37 a	450.53 a	469.08 a	489.08 a	26.21 a	28.052 a
Zink (0)	SA	0	278.29 c	306.12 d	313.67 d	333.67 d	17.63 f	16.537e
		50	318.00 ab	349.80 cd	361.28 cd	381.28 cd	20.60 ef	22.044 d
		100	332.52 ab	365.77 cd	378.69 cd	398.69 cd	22.55 cde	24.137 cd
		150	351.35 ab	386.49 cd	401.27 bcd	421.27bcd	24.58 a-d	26.309 bc
Zink (2g.L^{-1})	SA	0	332.68 ab	365.95 cd	378.88 cd	398.88 cd	21.00 def	22.472 d
		50	395.01 ab	434.51 abc	453.62 abc	473.62 abc	23.28 b-e	27.576 ab
		100	396.89 ab	436.58 cd	455.87 abc	475.87 abc	24.11a-e	25.807 bc
		150	373.28 ab	477.27 ab	494.22 ab	514.22 ab	26.9 abc	28.811 ab
Zink (4g.L^{-1})	SA	0	352.43 ab	387.67 cd	402.57bcd	422.57 bcd	25.82 abc	27.629ab
		50	355.93 ab	391.52bcd	406.76 bcd	426.76 bcd	26.44 ab	28.293 ab
		100	375.44 ab	412.98 abc	430.15 abc	450.15 abc	27.84 a	29. 037ab
		150	443.49 a	487.84 a	521.75 a	531.75 a	27.13 ab	29.799a

-Mean in each column followed by the same letters are not significantly different at P≤ 0.05 according to Duncan's multiple range test.

For the interaction, table 3 shows that the interaction between foliar application of Zink and SA increased weight and size of 100 berries and total soluble solid, the highest values (443.49 & 487.84; 487.84 & 521.75; 27.13 & 29.79) respectively for both season were resulted from the interaction of 4g.L^{-1} Zink + 150 mg.L^{-1} SA, while the lowest value (278.29 & 306.12; 306.12 & 313.67; 17.63 & 16.53) of number of clusters, cluster's weight and yield per vine for both season respectively, were obtained from the control. Increasing in berry size and weight may be due to the role of zinc in improvement fruit growth which has been effected by tryptophan and auxin synthetize (33).

4-Chemical characteristics*:* It's clear from Table 4 that Total sugar and juice percentage were increased significantly as foliar application of zink was increased. It is visible that treatment of 4g. L^{-1} gave the highest total sugar and juice percentage; it recorded 24.13 and 25.58; 68.07 and 73.51 % in the two seasons, respectively compare to the control which gave a lower significantly total sugar and juice percentage (19.21 and 19.36; 54.73&56.61) in both seasons, respectively. Also the same table shows that total acidity percentage was significantly decreased by increasing concentration of Zink, since the lower total acidity percentage (0.438 and 0.431) in the two seasons, respectively was obtained by application of 4g.L^{-1} compared to the highest total acidity percentage (0.663 and 0.651) for the two seasons, respectively was obtained by the control. Same table also clearly point to that total sugar and juice percentage were increased significantly as SA concentration was increased. It is obvious that treatment of 150 mg.L^{-1} SA gave the highest total sugar and juice percentage (23.60 and 25.01; 65.76& 71.02) for the both seasons, respectively, compared to the lowest values obtained with control (19.34&19.16; 57.05&71.02).

Table 4 Effect of foliar sprays of Zink and Salicylic acid on some chemical characteristics of grape cv. Halawni

Treatments			Total sugar (%)		Total acidity		Juice percentage	
			2017	2018	2017	2018	2017	2018
Zink ($g.L^{-1}$)		0	19.21 c	19.36 c	0.663 a	0.651 a	54.73 c	56.61 c
		2	21.45 b	22.74 b	0.451 b	0.43 b	62.00 b	67.80 b
		4	24.13 a	25.58 a	0.4382 b	0.431 b	68.07 a	73.51 a
Salicylic acid (SA) ($mg.L^{-1}$)		0	19.34 c	19.16 c	0.582 a	0.575 a	57.05 c	58.28 b
		50	21.10 bc	22.36 b	0.512 a	0.51 a	60.54 bc	66.50 a
		100	22.36 ab	23.70 ab	0.483 a	0.48 a	63.05 ab	68.09 a
		150	23.60 a	25.01 a	0.473 a	0.452 a	65.76 a	71.02 a
Zink (0)	SA	0	15.87 f	12.82 g	0.722 a	0.691 a	44.78 e	38.36 d
		50	18.54 def	19.65 f	0.684 ab	0.684 ab	56.34 d	60.85 c
		100	20.30 cde	21.52 def	0.642a-c	0.641a-c	57.54 d	62.14 c
		150	22.13 a-d	23.46 b-e	0.601a-c	0.606a-c	60.26 bcd	65.08 bc
Zink t ($2g.L^{-1}$)	SA	0	18.90 def	20.04 ef	0.541a-c	0.542a-c	59.04 cd	63.76 c
		50	20.95 b-e	22.21 c-f	0.442a-c	0.442a-c	61.31 bcd	69.55 bc
		100	21.71 a-e	23.01 a-d	0.385 c	0.38 c	63.67 bcd	68.77 bc
		150	24.23 ab	25.69 ab	0.423 bc	0.35 c	63.98 bcd	69.10 bc
Zink ($4g.L^{-1}$)	SA	0	23.24 abc	24.63 a-d	0.482a-c	0.484a-c	67.33 abc	72.72 ab
		50	23.80 abc	25.23 abc	0.425 bc	0.421a-c	63.97 bcd	69.09 bc
		100	25.06 a	25.89 ab	0.422 bc	0.423a-c	67.92 ab	73.36 ab
		150	24.42 ab	26.57 a	0.402 bc	0.405a-c	73.03 a	78.87 a

Mean in each column followed by the same letters are not significantly different at P≤ 0.05 according to Duncan's multiple range test.

Whereas, total acidity percentage was significantly decreased by increasing concentration of SA, since the lower total acidity percentage (0.473 and 0.452) in the two seasons, respectively was achieved by application of 150 $mg.L^{-1}$ compared to the highest total acidity percentage (0.582 and0.575) in the two seasons, respectively was obtained by the control. For the interaction, table 4 shows that the interaction between foliar application of Zink and SA increased Total sugar and juice percentage, the highest values (24.42 & 26.57; 73.03 & 78.87) respectively for both season were resulted from the interaction of $4g.L^{-1}$ Zink + 150 $mg.L^{-1}$ SA, while the lowest values (0.402 and 0. 405) of total acidity percentage for both season respectively, were obtained from the same interaction compared to the highest total acidity resulted from control (0.722 and 0.691). Data of table (5) clearly designate that juice density and β-carotenes was increased significantly as Zink concentration was increased. It is obvious that treatment of 4g. L^{-1} gave the highest values recorded (1.23 & 1.24: 27.87 and 25.50) in the two seasons, respectively, whereas, a lower significantly juice density and β-carotenes (1.10 and 1.11; 20.34 and 18.31) in both seasons, respectively were obtained from control. While, total phenols was decreased as Zink concentration was increased, the lowest total phenols (1.23 and 1.09) for both season respectively was resulted from application of 4g. L^{-1} Zink. Moreover, same table also clearly point to that juice density and β-carotenes were increased significantly as SA concentration was increased. It is apparent that treatment of 150 $mg.L^{-1}$ SA gave the highest juice density and β-carotenes (1.18 and 1.19; 26.42 and 24.78) for the both seasons, respectively, compared to the lowest values obtained with control (1.12&1.13; 22.87 and 20.58). Whereas, total phenols percentage was significantly decreased by increasing concentration of SA, since the lower total phenols percentage (1.24 & 1.09) in the two seasons, respectively was achieved by application of 150 $mg.L^{-1}$ compared to the highest total phenols percentage (1.34 & 1.31) in the two seasons, respectively was obtained by the control. For the interaction, table 5 shows that the interaction between foliar application of Zink and SA increased juice density and β-carotenes, the highest values (1.37 & 1.39; 30.92 and 27.83) respectively for both season were resulted from the interaction of $4g.L^{-1}$ Zink + 150 $mg.L^{-1}$ SA, while the lowest values (1.27 and 1.07) of total phenols percentage for both season respectively, were obtained from the same interaction compared to the highest total phenols (1.47) resulted from control in the first season and (1.42) resulted from the interaction between 2g.L^{-1} Zink and 0 mg.L^{-1} SA.

Table 5. Effect of foliar sprays of Zink and Salicylic acid on some chemical characteristics of grape cv. Halawni

Treatments			Juice density (OD) 2017	Juice density (OD) 2018	Total phenols (%) 2017	Total phenols (%) 2018	β-carotenes (mg.kg-1) 2017	β-carotenes (mg.kg-1) 2018
Zink (g.L^{-1})		0	1.10 b	1.11 b	1.33 a	1.21 a	20.34 c	18.31 c
		2	1.19 ab	1.17 ab	1.27 ab	1.20 ab	23.95 b	22.31 b
		4	1.23 a	1.24 a	1.23 b	1.09 b	27.87 a	25.50 a
Salicylic acid (SA) (mg.L^{-1})		0	1.12 a	1.13 a	1.34 a	1.31 a	22.87 b	20.58 b
		50	1.18 a	1.19 a	1.27 a	1.14 b	23.02 b	20.72 b
		100	1.20 a	1.18 a	1.26 a	1.13 b	23.91 ab	22.08 b
		150	1.18 a	1.19 a	1.24 a	1.09 b	26.42 a	24.78 a
Zink (0) SA	SA	0	0.99 b	1.00 b	1.47 a	1.39 ab	19.36 de	16.30 g
		50	1.20 ab	1.21 ab	1.32 ab	1.19 abc	18.11 e	17. 42 fg
		100	1.21 ab	1.22 ab	1.31 ab	1.18 abc	21.53 cde	19.37 d-g
		150	0.99 b	1.00 b	1.22 b	1.10 c	22.39 b-e	20.15 d-g
Zink t (2g.L^{-1})	SA	0	1.16 ab	1.17 ab	1.32 ab	1.42 a	24.06 bcd	21.65 c-f
		50	1.17 ab	1.18 ab	1.27 b	1.14 bc	23.73 b-e	21.35 def
		100	1.24 ab	1.15 ab	1.26 b	1.13 c	22.07 cde	19.86 d-g
		150	1.19 ab	1.20 ab	1.23 b	1.11 c	25.97 abc	26.37 abc
Zink (4g.L^{-1})	SA	0	1.21 ab	1.22 ab	1.24 b	1.12 c	25.19 bc	22.67 b-e
		50	1.18 ab	1.19 ab	1.21 b	1.09 c	27.23 abc	24.50 a-d
		100	1.16 ab	1.17 ab	1.21 b	1.09 c	28.15 ab	27.00 ab
		150	1.37 a	1.39 a	1.27 b	1.07 c	30.92 a	27.83 a

Mean in each column followed by the same letters are not significantly different at $P\leq 0.05$ according to Duncan's multiple range test

***5-* Mineral content:** Data of table (6) clearly demonstrations that, Zn and N percentage in leaf petiole and proline content in leaf of grapevine were increased significantly as Zink concentration was increased. It is observable that treatment of 4g. l^{-1} gave the highest values recorded (26.37 & 25.90; 1.68 &1.76; 1.87 &1.83) for the two seasons, respectively, whereas, a lower significantly Zn and N percentage in leaf petiole and proline content in leaf of grapevine (19.77 and 19.25; 1.23 & 1.29; 1.37 &1.40 in both seasons, respectively. Same table also clearly indicate that Zn and N percentage in leaf petiole and proline content in leaf of grapevine were increased significantly as SA concentration was increased. It is palpable that treatment of 150 mg.L^{-1} SA gave the highest Zn and N percentage in leaf petiole and proline content in leaf of grapevine (20.73 and 21.14; 1.40& 1.54; 1.56 and 1.51) for the both seasons, respectively, compared to the lowest values obtained with control. For the interaction, table 6 shows that the interaction between foliar application of Zink and SA significantly increased Zn and N percentage in leaf petiole and proline content in leaf of grapevine, the highest values (29.98 and 30.57; 1.84 and 1.69.75; 2.05 and 2.10) respectively for both season were resulted from the interaction of 4g.L^{-1} Zink + 150 mg.L^{-1} SA, while the lowest value (21.21 and 19.41; 1.23 and 1.22; 1.36 & 1.37) of Zn and N percentage in leaf petiole and proline content in leaf of grapevine for both season respectively, were obtained from the control.-

Table 6 Effect of foliar sprays of Zink and Salicylic acid on some mineral content of grape cv. Halawni

Treatments			Zn (mg.Kg-1) 2017	Zn (mg.Kg-1) 2018	N (%) 2017	N (%) 2018	proline (mg.kg-1) 2017	proline (mg.kg-1) 2018
Zink (g.L^{-1})		0	19.77 c	19.25 c	1.23 b	1.29 b	1.37 b	1.40 b
		2	22.82 b	23.53 b	1.33 b	1.37 b	1.47 b	1.55 b
		4	26.37 a	25.90 a	1.68 a	1.76 a	1.87 a	1.83 a
Salicylic acid (SA) (mg.L^{-1})		0	21.21 b	19.41 b	1.23 c	1.22 b	1.36 c	1.37 b
		50	22.79 ab	22.91 a	1.34 bc	1.44 ab	1.49 bc	1.44 b
		100	23.70 a	24.17 a	1.44 b	1.54 a	1.60 b	1.74 a
		150	24.26 a	25.08 a	1.64 a	1.69 a	1.82 a	1.84 a
Zink (0) SA	SA	0	15.82 c	12.47 c	1.01 f	0.85 e	1.12 g	1.15 f
		50	21.21 b	21.64 b	1.16 ef	1.28 b-e	1.29 fg	1.36 def
		100	21.33 b	21.76 b	1.36 cde	1.50 a-d	1.51 def	1.59 cde
		150	20.73 b	21.14 b	1.40 b-e	1.54 a-d	1.56 c-f	1.51 de
Zink (2g.L^{-1})	SA	0	23.84 b	24.32 b	1.18 ef	1.16 de	1.31 fg	1.38 def
		50	23.51 b	23.98 b	1.19 def	1.21 cde	1.32 efg	1.29 ef
		100	21.87 b	22.30 b	1.26 def	1.25 b-e	1.40 efg	1.64 cde
		150	22.08 b	23.53 b	1.68 ab	1.85 a	1.86 abc	1.90 abc
Zink (4g.L^{-1})	SA	0	23.96 b	21.44 b	1.50 bcd	1.65 abc	1.66 b-e	1.56 cde
		50	23.64 b	23.12 b	1.66 abc	1.83 a	1.85 abc	1.67 bcd
		100	27.89 b	28.45 a	1.72 ab	1.89 a	1.91 ab	2.00 ab
		150	29.98 a	30.57 a	1.84 a	1.69 ab	2.05 a	2.10 a

Mean in each column followed by the same letters are not significantly different at P≤ 0.05 according to Duncan's multiple range test

Data of Table (1 , 6) illustrations that leaf area and total chlorophyll of grapevine were increased by increasing Zink concentration; these may be to the role of Zn, since the Zink forms are essential for both enzymes and chlorophyll synthesis, accordingly, since it increase net photosynthetic rate and vegetative growth (21 , 26). The effect of SA on increasing leaf are and total chlorophyll may be attributed to the fact that salicylic acid works to accelerate the formation of chlorophyll and carotene pigments, accelerate the process of photosynthesis and increase the activity of some important enzymes, which is positively reflected on the leaf area and chlorophyll content (14). Recent evidence also suggests that SA is an important regulator of photosynthesis because it affects leaf and chloroplast structure (13 , 21), stomatal closure (12 , 21). Increasing yield and its components of grapevine which sprayed with Zn could be attributed to increase berry set, a number of berry in cluster and cell size or cell number resulting hence competition of photosynthetic substance between berries on a cluster (12). Also may be due to the role of zinc in improvement fruit growth which has been effected by tryptophan and auxin synthetize (23 , 35). Chemical components accumulate very rapidly with use suitable nutrition such as Zn. Zn found as a component of molecular structure of enzymes carbonic anhydridease which it is involvement in photosynthesis processes cause increase in the level of solids solution (12 , 23). SA is as an elicitor of phenolics and hydrolytic enzymes involved in grapevine defense (30). Moharekar *et al*., (22) described that, salicylic acid stimulate the synthesis of carotenoids and xanthophylls. Veraison is a major stage and a nature signal that initiates of grape berry developing and ripening. ABA (abscisic acid) hormone has the main role of berry ripening and its concentration increased during berry ripening. It is known that, there is an antagonistic direction between function of SA and ABA. SA application for grapevine berries delayed or inhibited ripening when applied at veraison stage. Researchers proven that, the increase in ABA level, which started at veraison, may causes the ripening of grape berry. Therefore, SA could inhibit the effect of ABA (11, 28, 29.) Some researches proved that salicylic acid enhanced membrane permeability would that, facilitate absorption and utilization of mineral nutrients and transport of assimilates. This would also participate towards increasing the capacity of the treated plants for biomass production as it reflected in increasing fresh and dry weight of plants. Therefore, the application of salicylic acid had increased total soluble sugar and other chemical contents (Chandra *et al*., 2007). The increased mineral contents in the leaves may be attributed to the role of salicylic acid in increasing the efficiency of the photosynthesis process and increasing the absorption of ions of the nutrient medium (14). Some researches proved that salicylic acid enhanced membrane permeability would that, facilitate absorption and utilization of mineral nutrients and transport of assimilates. This would also participate towards increasing the capacity of the treated plants for biomass production as it reflected in increasing fresh and dry weight of plants. Therefore, the application of salicylic acid had increased total soluble sugar (9).

REFERENCES

1-Abdel-Salam, M. M. 2016. Effect of foliar application of salicylic acid and micronutrients on the berries quality of ―bez el naka‖ local grape cultivar. Middle East Journal of Applied. 6(1):178-188.

2-Al-Atrushy, Sh. M. 2019. Effect of foliar application of micronutrients and canopy management on yield and quality of grapevine (*Vitis vinfera* L.) cv. Mirane. Iraqi Journal of Agricultural Sciences –1029:50(2):626- 637

3,Al-Atrushy, Sh. M. 2018. Grape Production. Duhok University press. Kurdistan region, Iraq.

4.Al-humdawy, A. M. S and Z.A.H.Alshamary . 2012. Effect of spraying nutrient solution and Salicylic acid on vegetative growth characteristics of Halawani Grape variety (*Vitis vinifera* L.). Kufa Journal for Agricultural Science. V (4) No. 1pp 65-80

5.Al-Rawi, K. M. and A. Khalafalla . 2000. Analysis of Experimental Agriculture Design. Dar Al-Kutub Print. Pub., Univ. Mosul . pp:: 448 . (In Arabic).

6.Alsaidi, I. H. 2000. Grape Production. Mosul university press.

7-Al-Sarwani, A. A, 2008. The Integrated Management of Grape Gardens, Arab ouse for Publishing and Distribution. Cairo, the Arab Republic of Egypt. (in Arabic).

8-Bybordi, A. and A. Shabanov. 2010. Effects of the foliar application of magnesium and zinc on the yield and quality of three grape cultivars grown in the calcareous soils of Iran. Sci. Biol., 2(1): 81-86

9-Chandra, A., A. Anand and A. Dubey. 2007. Effect of Salicylic Acid on Morphological and Fruit Quality. Iron Nutrition in Plants and Rhizospheric Microorganisms, Springer Netherlands. pp: 85-101.

10-Creasy, G.L. and L.L. Creasy .2009. Grapes - Crop Production Science in Horticulture. Oxfordshire, United Kingdom: CABI.

11-During, H., G. Alleweldr, and R. Kocu, 1978. Studies on hormonal control of ripening in berries of grapevines. Acta Hort . 80: 397-405.

12-Ebadi A.; atashkar D. and M. babalar 2001. Effect of Boron on pollination and fertilization in seedless grapevine cvs white seedless and iskari. Iranian Journal Agriculture Sciences. 32(2): 457-465.

13-Hassoon, A.S. and J.A. Abduljabbar. 2019. Review on the Role of Salicylic Acid in Plants. Open access peer-reviewed chapter. DOI: 10.5772/intechopen.89107.

14-Hayat, S.; B. Ali and A. Ahmad. 2007. Salicylic Acid: Biosynthesis, Metabolism and Physiological Role in Plants. Springer, Netherlands. pp.: 1-14.

15-Hidago, L.1980. L Viticulture dans Les pays semi-arides . Bull .O.I.V.598:845-971 .

16-Jamal al-Din, F. A. 2010. Encyclopedia of Medicinal Plants. Second Edition . Knowledge facility. Alexandria . The Egyptian Arabic Republic.

17-Jonathan, M., 2012. Impact of Marine Extracts Application on cv. Syrah Grape Yield Components, Harvest Juice Quality Parameter and Nutrient Uptake. M.Sc. Thesis. Polytechnic State University, California.

18-Kamiloglu, O. 2011. Influence of some cultural practices on yield, fruit quality and individual anthocyanin of table grape c v. Horoz Karasi. J. Anim. Plant Sci. 21. pp.: 240–245.

19-Marschner H. 1995. Mineral Nutrition of Higher Plants. 2nd ed. Academic Press. New York.

20-Mateo A, D. Funck , P. Mühlenbock , B Kular , PM. Mullineaux and S, Karpinski . Controlled levels of salicylic acid are required for optimal photosynthesis and redox homeostasis, Journal of Experimental Botany, 2006, vol. 57 ; pp. 1795-1807.

21-Melotto M, W.UnderwoodW., J. Koczan , K. Nomura K, and S.Y. He . 2006. Plant stomata function in innate immunity against bacterial invasion, Cell , l. (126): 969-980.

22-Moharekar, S.T., S.D. Lokhande, T. Hara, R. Tanaka, A. Tanaka and P.D. Chavan, 2003. Effect of salicylic acid on clorophyll and carotenoid contents of wheat and moong caryopsis, Photosynthetica, 41: 315-317

23-Nikkhah, R.; H. Nafar, S.Rastgoo and M. Dorostkar. 2013. Effect of foliar application of boron and zinc on qualitative and quantitative fruit characteristics of grapevine (*Vitis vinifera* L.). Int. J Agric. Crop Sci. . 6 (9), 485-492.

24-OIV 2017. statistical report on world viticuilture. World viticulture situation. P:8..

25-Pestana .M; P.J. Correra; A. Devaremnes; J. Abadia and E. A. Faria. 2004. Floral analysis as a tool to diagnose iron chlorosis in orange trees. Plant and Soil 259: 287–295.

26-Pestana, M., M. David, A. deVarennes, J. Abadı´a, and E.A. Faria. 2001. Responses of newhall' orange tree stair on deficiency in hydroponics: effects on leaf chlorophyll, photosynthetic efficiency and root ferric chelate reductase activity. Journal of Plant Nutrition, 24: 1609-1620

27-Prabhu P.C, and P. Singaram 2001. Effect of micronutrients on growth and yield of grapes cv. muscat. Madras Agriculture Journal. 88(1-3). Pp: 45-49.

28-Raskin, I. 1992. Role of salicylic acid in plants. Annual Review Plant Physiology, 43, 439–463.

28-Ray, S.D., 1986. GA, ABA, phenol interaction and control of growth: Phenolic compounds as effective modulators of GA-ABA interaction in radish seedling. Biol. Plant., 28: 361-369.

30-Renault, A.S., A. Deloire and J. Bierne, 1996. Pathogenesis-related proteins in grapevines induced by salicylic acid and *Botrytis cinerea.* Vitis, 35: 49-52

31-SAS Institute. 2015. Base SAS 9.4 Procedures Guide. SAS Institute.

32-Uzunova AN and L.P. Popova .2000.. Effect of salicylic acid on leaf anatomy and chloroplast ultrastructure of barley plants, Photosynthetica .. 38 : 243-250

33-Wojcik P and M. Wojcik . 2003. Effects of boron fertilization on conference pear tree vigor, nutrition, and fruit yield and storability. Plant and Soil, 256: 413-421.