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RESEARCH ARTICLE

The effect of spraying certain anti-stress agents on growth performance and fruit quality of Superior grapevines

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Abstract

This study was carried out during two successive seasons of 2022 and 2023 to clarifying the effect of citric acid, salicylic acid, boron, potassium silicate and amino acids on vegetative and fruiting of "Superior" seedless grapevines. The experiment was set up in a complete randomized block design with six treatments, three replicates, and two grapevines each. Citric acid and salicylic acid at 1500 ppm, boron at 500 ppm, potassium silicate at 3000 ppm and amino acids at 2000 ppm were applied on clusters and leaves, three times a year, when the vegetative growth reaches 20 cm, after berry set and one month later. Application forms of amino acids, boron, and potassium as well as citric and salicylic acids significantly stimulated the vegetative growth traits more than untreated ones (control). Also, all treatments significantly increased the yield components to untreated ones (control). Moreover, they significantly improved the berry juice in terms of raise total soluble solids (TSS) and sugar contents and decreased the total acidity. Hence, it could be concluded that foliar application of salicylic acid, citric acid, boron, potassium silicate and amino acids, are useful in the improvement of nutritional status and productivity of grapevines, where that may be tolerated the harmful effects of heat stress.

Keywords: potassium silicate; amino acids; yield; heat stress; Superior grapevine

1. Introduction

Grapevines are considered one of the first major fruit trees cultivated across the globe. With 206 million tons of fruits produced annually, the world's total fruiting area and production amounted to 11.0 million hectares (FAO, 2018). Specifically, on reclaimed lands, grapes are the third most popular fruit crop in Egypt, after citrus and mangoes., It reached around 186735 feddan, with the fruitful ones being about 175245 feddan. The overall annual production of grabs was 1715410 tons according to M.A.L.R. (2023). The grapevines need good soil, a suitable climate, and optimal horticultural procedures. Potential effects of the impending climate change include the rise in the average yearly temperature and the accumulation of extreme weather conditions, such as frequent and intense heat waves, which is referred to as global warming. The primary cause of climate change, and more specifically, global warming, is acknowledged to be the emissions of greenhouse gases, particularly CO_2, brought on by various human activities (Raza *et al*., 2019; Venios *et al.*, 2020). Abiotic stressors are caused by changes in climatic trends and include a range of environmental factors that hinder the development of fruiting pennants. Due to their detrimental impact on berry ripening, excessive temperatures are likely to lower berry quality and economic income. Abiotic stressors have a significant impact on plant development and agricultural output, accounting for almost 50% of global main crop yield loss each year. It is a significant worldwide issue that restricts crop productivity (Kumari *et al.*, 2019b). In an open field setting, where all of these environmental factors are interrelated, it can be challenging to discern the distinct effects of each of the most prevalent abiotic stresses, which include high temperatures, droughts, salinities, soil acidification, and extreme radiation exposure

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(Skirycz and Inzé, 2010; Kumari *et al.,* 2019a). There have been numerous attempts to mitigate the negative impact of heat stress on grapevine productivity and berry quality when cultivated in hot climates. Thus, heat stress damage can be prevented by utilizing certain anti-stress agents, amino acids, or substances containing them. Since silicon increases a plant's tolerance to climatic circumstances, potassium silicate is essential to the plant. Additionally, it contains potassium, a crucial component for the plant. It is advised to use foliar spraying with silicate potassium to shield plants from heat stress (Bakhat *et al.,* 2018). Application of Si plays a pivotal role in improving nutritional status of both monocot and dicot plants as well as an ecologically compatible and environmentally friendly technique to stimulate plant growth directly or indirectly by combating various biotic and abiotic stresses (Lipa and Pranab 2022). Potassium plays a crucial role in many different plant processes and is necessary for grapevine growth and fruiting. According to Fogac *et al.,* (2007) and Cuéllar *et al.* (2013), it may play a role in the transportation and utilization of carbohydrates as well as serve as an osmotic agent in the opening and closing of stomata, an essential aspect of vine water balance and tolerance to heat stress. Citric and salicylic acids are two examples of antioxidants that are crucial for the production of the majority of organic foods, cell division, and plant defense against oxidative stress. Under field conditions, their practical application in fruit trees is rather feasible. They are highly advantageous for preventing free oxygen and lowering cell senescence, protecting cells from senescence, promoting cell division and organic food production, and lowering the frequency of fungal invasion. Additionally, antioxidants could be employed to make organic fruits and reduce environmental pollution in place of auxins and pesticides. Numerous plant development responses under environmental stress conditions can be efficiently regulated by adding citric acid through foliar spraying or soil application (Tahjib-Ul-Arif *et al.,* 2021; Beheiry *et al.,* 2023). The development and productivity of King ruby vines were examined in relation to the effects of foliar spraying with antioxidants, such as citric acid and/or ascorbic acid at 500 ppm. When compared to the control, there was a considerable improvement in shoot length, leaf area, yield/vines, fruit quality, leaf chlorophyll, and leaf mineral contents (Belal, 2015). Salicylic acid is one phenolic molecule that controls plant growth and development as well as how they react to biotic and abiotic stressors. It protects plants from abiotic stressors by regulating key physiological processes like photosynthesis, nitrogen metabolic processes, proline metabolism, glycine betaine synthesis, the protective antioxidant system, and plant-water relationship under stress (Khan *et al.,* 2012b; Kumar, 2014; Miura and Tada, 2014**).** Salicylic acid has been demonstrated to increase plant resistance to important abiotic stressors, including drought **(**Fayez and Bazaid, 2014), heat stress (Khan and Khan, 2014), osmotic stress (Naser Alavi *et al.,* 2014), salinity (Khan and Khan, 2014; metal Zhang *et al.,* 2015). Boron plays a role in the development of plant reproductive organs, including pollen tube growth, seed generation, and the transfer of carbohydrates like sugar. Additionally, it is essential for the division of cells and expansion, the movement of ions across membranes, phenol metabolism and transport, and the structural and functional integrity of cell walls and membranes (Shireen *et al.,* 2018). The process of flowering and fruiting depends on the vine having sufficient amounts of boron. One of the greatest prevalent deficits in grapevines is low boron concentrations or absence, which results in a notable decline in grape quality. Particularly in sandy soil with low B concentration, boron fertilizer increases yield (Gupta and Solanki, 2013). Small berries and poor fruit set are the most typical symptoms of a boron shortage (Tariq *et al.,* 2007). Due to its high solubility and leaching by irrigation or rainfall in shallow or coarse-textured soils, boron availability for plants is restricted (Zhou *et al.,* 2014). Proteins, cell division, pigments from plants, and naturally occurring hormones like ethylene, GA_3, and IAA are all improved by amino acids. In the physiological processes involved in plant growth and development, amino acids can have a direct or indirect impact. Growth and fruiting had been enhanced by the exogenous spraying of amino acids (Rai, 2002; Khan *et al.,* 2012a). Thus, the purpose of this study was to improve the ability of Superior grapevines cv to produce fruits at hot temperatures and investigate the impact of various treatments to tolerate the negative effects of heat stress.

2. Materials and Methods:

The present study was conducted on a 14-year-old Superior seedless grapevine on clay soil at the experimental orchard Faculty of Agriculture, South Valley University, Qena Governorate, 30.42°N, 31.48 E, Egypt, throughout two seasons of 2022 and 2023. Every chosen vine was planted at a 2 x 3 m spacing. The vines were trained on arbors (Spanish type) using the conventional cane pruning method. Using a cane pruning system, the winter pruning system was completed at the end of December, leaving 96 buds (8 fruiting canes x 10 buds + 8 renewal spurs x 2 buds). With the exception of the current treatments, the vines were subjected to standard horticultural procedures, including fertilizer, irrigation, and the control of weeds and pests. Additionally, each vine retained the top 40 bunches from the two seasons. To conduct this study, 36 vines that were nearly consistent in vigor and showed no outward signs of nutrient deficiencies were selected and split. A complete randomized block design (CRBD) was used to organize experimental vines, with two vines in each of the three replications for each treatment.

The six different treatments were as follows:

1- Control (T_1).
2- Salicylic acid at (1500) ppm (T_2).
3- Citric acid at (1500) ppm (T_3).
4- Boron (500) ppm (T_4).
5- Amino acids at (2000) ppm (T_5).
6- Potassium silicate at (3000) ppm (T_6).

The amount of each foliar spray compound was chosen according to producers recommendations and previous investigations.

Salicylic Acid was: 2-hydroxybenzoic acid, Molecular Weight: 138.12 g/mol.

Citric Acid was: 2-hydroxypropane-1,2,3-tricarboxylic acid, Molecular Weight: 192.12 g/mol.

Boron as boric acid, H_3BO_3, Molecular Weight: 61.83 g/mol. It contains 17.48 % Boron.

Amino acids were a (commercial product produced by: Union for Agricultural Development Co. (UAD), Egypt). It contains 17.5 % amino acid mixture W\V (Aspartic acid 1.56%, Threonine 1.08%, Serine 2.045, Glutamic acid 2.40%, Alanine 1.75%, Valine 1.37%, Isoleucine 0.61%, Leucine 0.69%, Histidine 0.18%, Argenine 1.45%, Proline 1.97%, Phenylalanine 0.67%, Glycin 1.04%, Lysin 0.49%, Tyrosin 0.23%).

Potassium silicate was K2O5Si2, Molecular Weight: 154.279 g/mol. It contains (10 % kO2+25 % silicon oxide). Meteorological data on Qena region during 2022 and 2023 seasons are presented in Table (1).

Table 1. Temperatures and humidity for Qena governorate during 2022 and 2023 seasons

Qena, Egypt Weather History													
	Year	2022						2023					
	Month	Temperature (°C)			Humidity (%)			Temperature (°C)			Humidity (%)		
		Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min
1	January	24.35	16.31	8.32	73.71	51.19	28.71	19.71	13.22	6.39	69.06	48.57	26.35
2	February	25.04	18.02	10.54	65.82	45.16	26.50	23.54	16.20	8.68	63.46	41.93	21.50
3	March	30.03	21.98	13.06	52.65	34.02	17.55	26.87	19.32	10.94	48.10	30.11	14.42
4	April	35.23	27.27	17.57	39.13	24.08	12.20	37.97	29.44	19.70	31.70	19.27	8.90
5	May	40.23	33.57	25.77	35.29	22.66	14.03	38.45	31.13	21.94	31.71	19.21	9.45
6	June	40.67	33.66	26.13	35.00	22.45	12.40	40.17	33.57	25.40	35.70	23.52	12.97
7	July	41.16	34.67	26.42	35.58	23.66	13.16	40.87	33.67	25.77	36.65	24.21	13.48
8	August	41.61	34.31	26.84	37.10	23.77	13.84	41.10	34.38	27.10	39.35	27.47	16.19
9	September	38.40	31.67	24.93	45.10	30.57	17.97	39.07	31.93	23.83	46.17	30.82	17.30
10	October	35.45	27.91	20.81	53.23	34.27	20.35	33.87	27.39	21.30	55.07	37.55	22.87
11	November	30.63	22.99	15.93	57.10	40.36	24.30	28.13	21.54	15.30	60.40	42.27	26.87
12	December	22.97	16.22	9.48	65.94	47.45	26.90	24.81	17.75	10.32	66.42	48.28	29.61

The following metrics were examined in order to assess how various treatments affected berry quality, yield, growth, and nutrient status.

2.1. Vegetative growth criteria

All vegetative growth criteria, leaf area and pruning wood weight (kg/vine), and proline in leaves were measured in the mid of July.

2.2. *Leaf area (cm^2)*

In order to estimate the leaf area using the following equation, a sample of ten mature leaves from each plant were taken from the top of the developing shoot (6th or 7th leaf): The leaf area (cm2) was determined using the formula L = leaf blade length and W = leaf blade width (Montero et al., 2000) = 0.587 (L×W). In mid-July, mature leaves were removed from the tops of shoots, and the petioles of the leaves were separated from the blades. Before being processed in a stainless steel mill, the petioles were cleaned with tap water, desilted water, air dried, and oven dried at 70°C to constant weight. Hydrogen peroxide and strong sulfuric acid were used for overnight wet digestion. In the digestion, the percentage of free proline in the leaf tissues was calculated using the Bates *et al.* (1973) recommended method.

2.3. Leaf chlorophyll content

At the mid-July 10 fully mature leaves/vine were taken from each vine/replicate to determine SPAD chlorophyll index using a portable chlorophyll meter (Minolta-SPAD-502plus, Minolta, Japan) Ling, *et al.,* (2011).

1. Yield: At harvest date, the yield per vine was recorded in terms of weight (kg) per vine.
2. Cluster and berry characteristic:

To determine the cluster and berry characteristics, two clusters were randomly selected from each vine on harvest day. A.O.A.C. techniques (1985) were used to determine berry quality, which includes berry weight, reducing sugar percentages, total soluble solids, and total acidity (measured as g tartaric acid per 100 ml juice). According to Steel and Torrie (1980), all of the collected data were tabulated and examined using the New L.S.D. test in accordance with Gomez and Gomez (1984) in order to identify any significant differences between the means of the various treatments.

3. Results

3.1. *Vegetative growth and leaf nutritional status*

Generally, data showed that amino acids and potassium as well as citric and salicylic acids spraying significantly increased the weight of pruning wood, leaf area, potassium and proline contents of leaves compared to the control (Table 2,3). The maximum values of pruning wood weight, leaf area, K% and proline % were recorded for amino acids (T5) and potassium silicate spraying (T6). On the other hand, the lowest amount of the growth criteria as well as K and proline contents were obtained on the vines that were untreated (check vines). Then the highest pruning wood weight was (1.90 & 1.95 kg/vine), leaf area (134.09 &137.45 cm^2), K% (0.69 & 0.75%) and proline % (47.01 & 45.44% as average. of two studied seasons), respectively. On other hand, the least ones due to control (T1) was (1.82 kg/vine, 101.74 cm^2, 0.59% and 37.71%), respectively. Therefore, the corresponding increment of pruning wood was (17.28 & 20.37%), leaf area (32.09 & 35.10%), K% (20.34 & 23.73%) and proline % (24.16 & 20.50%), due to T5 and T6 compared to the control (T1) in the two studied seasons, respectively. No significant variation seen in pruning wood weight and leaf area for potassium or amino acids spraying. On other hand, the highest values of leaf K % and leaf-proline were seen for amino acids spray.

Therefore, spraying of potassium silicate and amino acids significantly improved the total leaf surface area, nutritional status and vegetative growth of vines as well as reduced the adverse effects of heat stress. Certainly, the positive effects of these treatments on improving growth and nutritional status due to resisting the heat stress bad. It will improve production and berry characteristics.

Table 2. Effect of Salicylic acid, Citric acid, Boron, Silicate potassium and amino acids, on some vegetative growth aspects of Superior grapevines during 2022 and 2023 seasons

Treatment	Leaf area(cm^2)			Total chlorophyll (SBAD)			Pruning wood weight (kg/vine)		
	2022	2023	Mean	2022	2023	Mean	2022	2023	mean
T1	105.61d	97.87c	101.74c	28 c	33.33 d	30.67 c	1.63 b	1.61 b	1.62 b
T2	117.60 bc	135.23a	126.42b	31.77b	34.67 cd	33.22 b	1.89 a	1.84 a	1.87 a
T3	125.89 b	123.85 b	124.87b	33 b	35.33 bcd	34.17b	1.84 a	1.82 a	1.83 a
T4	113.10 cd	129.03 ab	121.07b	31.60 b	37.33 ab	34.4 b	1.86 a	1.86 a	1.86 a
T5	136.50 a	131.68 ab	134.09a	37.47 a	38.33a	37.90 a	1.93 a	1.88 a	1.90 a
T6	138.73 a	136.17 a	137.45a	34.33 ab	36.97 ab	35.62 ab	1.98 a	1.93 a	1.95 a
LSD	9.09	8.58	6.36	4.03	2.22	2.36	0.18	0.19	0.13

T_1 = control; T_2= Salicylic acid; T_3= Citric acid;T_4= Boron ; T_5=amino acids ; T_6= Silicate potassium

Table 3. Effect of Salicylic acid, Citric acid, Boron, Silicate potassium and amino acids, on potassium and proline contents of Superior grapevines during 2022 and 2023 seasons

Treatment	K%			Proline, %		
	2022	2023	Mean	2022	2023	Mean
T1	0.55 d	0.63 c	0.59 c	35.86 d	39.55 c	37.71 d
T2	0.61 c	0.70 b	0.66 c	40.39 c	45.18 b	42.79 c
T3	0.65 b	0.72 ab	0.69 b	43.1 b	44.87 b	43.99 c
T4	0.66 b	0.73 ab	0.70 b	43.25 b	47.11 ab	45.18 bc
T5	0.65 b	0.76 a	0.71 a	45.63 a	48.38 a	47.01 a
T6	0.72 a	0.74 ab	0.73 a	44.18 ab	46.72 ab	45.44 b
LSD	0.04	0.05	0.03	1.73	1.92	1.38

T_1 = control; T_2= Salicylic acid; T_3= Citric acid; T_4= Boron; T_5=amino acids; T_6= Silicate potassium

3.2. *Yield and cluster characters*

Potassium silicate and amino acids as well as boron and salicylic and citric acids significantly increased the yield/vine, cluster weight and berry weight compared to untreated treatment (Table 4). The highest values of cluster weight were (496.32 & 505.19 g) and yield/vine (21.5 & 25.33 kg/vine as mean of the two seasons) for spraying amino acids (T5) and potassium silicate (T6), respectively. Contrarily, these values on untreated vines were (380.50 g and 16.83 kg/vine), respectively. Then the harmonious increment percentages for these features over untreated were (30.44, 32.77%); (27.75, 50.51%), respectively. Moreover, no significant difference was recorded due to using any of amino acids or potassium silicate. Also, the treatments significantly increased the berry weight compared to the control. The corresponding increment percentage of berry weight attained (11.29 & 18.22%), respectively.

Table 4. Effect of Salicylic acid, Citric acid, Boron, Silicate potassium and amino acids, on cluster weight, yield/vine, and berry weight (g) of Superior

Treatment	cluster weight			yield/vine			berry weight (g)		
	2022	2023	Mean	2022	2023	Mean	2022	2023	Mean
T1	419.00 c	342.0 c	380.50 c	17.00 d	16.67 c	16.84 d	3.66 c	3.78 c	3.72 d
T2	527.67 ab	424.0 b	475.84 b	19.67 c	18.67 bc	19.17 c	4.17 b	4.17 b	4.17 c
T3	517.67 b	420.7 b	469.19 b	20.67 c	18.67 bc	19.67 c	3.99 b	4.13 b	4.06 c
T4	519.67 b	423.7 b	471.69 b	20.67 c	18.33 bc	19.50 c	4.05 b	4.11 b	4.08 c
T5	548.33 a	444.3 a	496.32 a	23.00 b	20.00 b	21.50 b	4.03 b	4.47 a	4.25 b
T6	549.67 a	454.7 a	502.19 a	25.33 a	25.33 a	25.33 a	4.40 b	4.58 a	4.51 a
LSD	26.48	18.71	16.29	2.10	2.78	1.76	0.31	0.26	0.21

T_1 = control; T_2= Salicylic acid; T_3= Citric acid; T_4= Boron; T_5=amino acids; T_6= Silicate potassium

3.3. *Berry quality*

All Spraying significantly improved the berry juice in terms of raise total soluble solids (TSS) and sugar contents and decreased the total acidity compared to untreated one (control). The highest total soluble solids (13.82 & 14.01%), reducing sugar (13.88 & 13.69%) and the lowest total acidity (0.315 & 0.334%) due to amino acids or silicate potassium spraying. Hence the corresponding increment percentage of TSS attained (18.12 & 19.74%), respectively.

Table 5. Effect of Salicylic acid, Citric acid, boron, potassium silicate and amino acids, on berry juice of Superior grapevines during 2022 and 2023 seasons.

Treatment	TSS			Sugar			Acidity		
	2022	2023	Mean	2022	2023	Mean	2022	2023	Mean
T1	11.97 b	11.42 d	11.70 c	11.65 b	11.42 d	11.54 c	0.479 a	0.325 a	0.402 a
T2	13.60 a	12.73 bc	13.17 a	11.91 b	12.73 bc	12.32 b	0.413 bc	0.278 b	0.346 b
T3	12.80 ab	12.55 cd	12.68 b	13.29 ab	12.55 cd	12.92 b	0.407 bc	0.250 b	0.329 b
T4	13.50 a	13.92 ab	13.71 a	14.70 ab	13.92 ab	14.31 a	0.403 bc	0.225 b	0.327 b
T5	13.57 a	14.07 A	13.82 a	13.70 a	14.07 a	13.89 a	0.417 b	0.263 b	0.334 b
T6	14.03 a	13.99 a	14.01 a	13.39 a	13.99 a	13.69 a	0.380 c	0.228 c	0.315 b
LSD	1.30	1.26	.93	1.78	1.28	1.10	0.033	0.065	0.037

T_1 = control; T_2= Salicylic acid; T_3= Citric acid; T_4= Boron; T_5=amino acids; T_6= Silicate potassium.

4. Discussion

Overall, the temperature of 25 to 32°c is the optimal range for grapevine growth (Ferrini et al 1995). The temperature below this optimal range limits vegetative development. Temperatures over the optimal range affect the balance of berry quality and reduce the rate of photosynthesis by increasing respiration. Increased temperatures cause an imbalance in the accumulation of sugar and anthocyanin, which lowers berry quality and yield (Jones et al., 2004). Stress from extreme temperatures affects blooming, slows berry growth, and prevents sugar accumulation, which delays harvest and lowers berry quality and output. Given a persistent decline in net the process of photosynthesis these results could be explained (Soar *et al.*, 2009; Greer and Weston, 2010; Greer and Weedon, 2012 and Greer, 2019). Potassium silicate significantly increased in all vegetative growth and leaf nutritional status table (2,3), the yield and cluster characters' table (4) and berry quality table (5) compared to all treatment and control, this may be due to Potassium to be of special importance for the growth, flowering and fruiting of all fruit trees. Additionally, it protects plants from biotic and abiotic stressors by maintaining turgor, reducing wilting and water loss, and increasing cold tolerance Because it is involved in metabolic activities like the synthesis of proteins and carbohydrates, the stimulation of enzymes, membrane transport, charge balancing, and the production of turgor pressure, potassium is an important element (Martin *et al*., 2004 ; Dordas, 2008). When potassium levels in vineyards are at their ideal levels, yields rise, and berry characteristics improve. These findings concur with those of Belal *et al*. (2017); El-Badawy (2019); Ahmed-Mona (2020). The significant increase of boron reason can be explained by its role in enhancing meristematic tissue cell division, leading to greater leaf production and an intensified photosynthetic rate. This, in turn, promotes further cell proliferation and expands leaf surface area (Galet, 1983; Rasul, 2008). Additionally, boron stimulates photosynthesis, facilitating sugar synthesis in leaves and their subsequent translocation to flowering and fruiting clusters. This ensures optimal cluster nutrition, improving the nutrient allocation per flower cluster—whether newly formed or developing, thereby minimizing inter-cluster competition for leaf-derived nutrients and hormones. Consequently, this process enhances cluster development and increases cluster weight (Al-Saeedi et al., 1994; Rasul, 2008).The present study suggested that amino acids spraying and then potassium and calcium had significant impacts on fruit length and diameter. The results of the current study concerning the positive effective effect of amino acids on fruit dimensions have been confirmed by Khattab *et al*. (2012) and Wassel *et al*. (2015). Davarpanah *et al*. (2017 that potassium as foliar application significantly increased fruit dimensions of pomegranate. The positive effect of calcium spraying on fruit dimensions has been reported by Khalil and Aly (2013), Ahmed *et al*. (2014), Maji *et al*. (2017) and Davarpanah *et al*. (2018). The results of the current study demonstrate that foliar of amino acids has an obvious effect in terms of improving the vegetative growth attributes, fruit set, fruit yield, fruit quality, and nutritional status this result may be due to The physiological processes involved in plant growth and development can be influenced by amino acids either directly or indirectly. They are regarded as precursors and components of proteins, which are crucial because they promote cell division. Furthermore, the development, yield, and biochemical quality of fruit have all been influenced by the exogenous administration of amino acids (Rai, 2002; Shiraishi *et al*., 2010; Khan *et al*., 2012), Amino acids are crucial for improving vine nutritional status and growth, and their beneficial effects on boosting physiological activity undoubtedly contributed to improved fruit quality, growth, and maturity. These findings contradict those of Abdel-Aal *et al*. (2010), Khan *et al.* (2012) and Khan *et al.* (2019). It can be noticed that salicylic acid gained the highest significant value compared with the control. In this connection, this increase may be due to the role of salicylic acid in activating cell division, biosynthesis of organic foods, and availability as well as the movement of mineral nutrients toward the leaves (El-Shazly *et al*. 2015; Metwaly and El-Shatoury, 2017). These results are agreeable with those reported by Cornelia et al. (2010); El-Shazly *et al*. (2015); Khoshbakht and Asgharei (2015); Metwaly and El-Shatoury (2017); Zaky *et al.* (2018). These findings might be due to tolerance harmful effects of heat stress that cause enhanced maturity. According to the present results it could be recommended that spraying vines with potassium silicate or amino acid sources to improve the berries quality, where that tolerance the harmful effects of heat stress.

5. **Conclusion**

Salicylic acid, citric acid, boron, potassium silicate, and amino acids can be applied topically to grapevines to improve their nutritional status. This resulted in a high crop with good cluster traits and berry quality that was able to withstand the negative effects of heat stress.

Declarations

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All authors are contributed in this research
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Institutional Review Board Statement
All Institutional Review Board Statements are confirmed and approved.
Data Availability Statement
Data presented in this study are available on fair request from the respective author.
Ethics Approval and Consent to Participate
Not applicable
Consent for Publication
Not applicable.
Conflicts of Interest
The authors disclosed no conflict of interest.

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