

Influence of Fruit Thinning and Foliar Sprays of Salicylic Acid, Nano-Calcium and Boron on the Qualitative Characteristics of Zaytouni variety (*Vitis vinifera* L)

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Abstract

The experiment was conducted during the growing season (2024) in a private orchard in the Dibs district of Kirkuk province to determine the effect of fruit thinning and spraying with salicylic acid, nano-calcium, and boron on the qualitative characteristics of grape fruits of Zaytouni variety. The experiment was carried out in a factorial manner according to the R.C.B.D design of randomized complete blocks with a split-split plot system. The study included three factors: the first was fruit thinning at three levels: (without thinning), (total thinning), and (partial thinning). The second factor was spraying with salicylic acid at three levels: (control) (without spraying), (75 mg L⁻¹), and (150 mg L⁻¹). The last factor included spraying with nano-calcium and boron: (control) spraying with water only, spraying with (45 mg L⁻¹ of boron), and spraying (150 mg L⁻¹ of nano calcium). The results showed that treatment (partial thinning) significantly excelled in cluster diameter and TSS, while treatment (total thinning) significantly excelled in cluster length, TSS, total sugars and anthocyanin content of the fruit. As for treatment (without thinning), it recorded a significantly excelled in total acidity percentage. As for the treatment with salicylic acid, (150 mg L⁻¹) recorded a significantly excelled in cluster diameter and total sugars content of the fruit. As for the third factor (spraying with nano calcium and boron), no significant differences were recorded in the studied traits. As for bi- interaction, treatment A2B2 was excelled in anthocyanin pigment. The interaction treatment A2B3 recorded a significantly excelled in cluster length, TSS percentage and total sugars percentage, while A3B3 recorded a significantly excelled in cluster diameter, while the interaction between A1B1, A1B2 and A1B3 recorded a significantly excelled in total acidity percentage in fruits. The interaction A3C1, A3C2, and A3C3 was excelled in cluster diameter and TSS, while the interaction (A2C1, A2C2, and A2C3) was excelled in cluster diameter, TSS, and total sugars. The interaction A2C2 was excelled in anthocyanin content of the fruit, and the binary interaction factor A2C3 was significantly excelled in cluster length, while (A1C1, A1C2, and A1C3) recorded a significantly excelled in the total acidity of the fruit. The interaction B3C2 was excelled in the total sugars and anthocyanin content of the fruit. As for the triple interaction A2B3C3, it was significantly excelled in cluster length, TSS, and total sugars. The interaction A3B3C3 was significantly excelled in cluster diameter and total soluble solids. As for total acidity, the interaction between A1B2C2 significantly excelled. As for the anthocyanin content of the fruit, several treatments recorded significantly excelled, the most important of which was A2B3C2.

Keywords: Grapevines, Qualitative, Salicylic acid, Nano-calcium and Boron, Fruit thinning.

1-Introduction

Grapes (*Vitis vinifera* L.) belong to the Vitaceae family, which includes (14) genera, the most important of which is the genus (*Vitis*), which is the most important crop from an economic and commercial standpoint and the largest in terms of production compared to various fruit crops [1]. Grapes have a high nutritional value, a distinctive taste, and their multiple uses have given them great importance and good economic returns. They are a good source of vitamins such as vitamin C, vitamins B1 and B2, nutrients, and sugars. They have multiple and unique uses that no other fruit can surpass [2]. It has been scientifically proven that grapes are of great importance to human health due to their effectiveness as a substance that reduces the risk of vascular and heart diseases and other chronic diseases due to their high content of effective antioxidants such as polyphenols, which include Resveratrol, tannins, anthocyanin, and flavonoids [3] are also anti-inflammatory, antimicrobial, anti-cancer, anti-catarhal, anti-allergic, anti-kidney disease and anti-aging substances [4]. Grapes are of great economic importance in exploiting different types of soils, including low-fertility, shallow, and sandy soils. They are also important in preventing erosion and stabilizing the soil compared to other fruit types, as well as continuing to bear fruit for decades (50-60) years or more [5]. Cluster thinning is an important agricultural practice. First, it provides fewer growing days for cold climates due to short seasons, which limits the vines' ability to ripen the fruit [6]. For this reason, the need for a larger leaf area for full fruit ripening has been proposed [7]. Cluster thinning provides high- and

medium-yielding varieties with a strategy to reduce yields and produce high-

quality fruit [8]. Second, some *Vinifera* grape varieties and hybrid varieties often produce two clusters on each fruiting branch. In varieties such as Sangiovese and Montepulciano, vines are often unable to ripen these additional fruits to their ideal maturity level due to their delayed development and small size, which makes the grape vines weak compared to the few clusters. Terminal clusters are removed in these high-yielding varieties, thus improving the absorption capacity of the remaining clusters and allowing them to reach early maturity [9 and 10]. Salicylic acid also plays a role in regulating plant physiological activities such as growth, carbon metabolism, nitrite metabolism, ethylene production, and flowering. Salicylic acid is considered a growth regulator that has a significant impact on most biological processes and is influential in photosynthesis. Much research indicates that salicylic acid has a positive role in reducing stress, as it reduces the ratio of sodium to potassium in the roots, thus increasing water potential. Water content in treated leaves in concentrations of it, it increases the accumulation of chlorophyll and carotenes in the plant [11 and 12]. Foliar spraying is spraying solutions of nutrients on the green group at the appropriate time and in appropriate concentrations to help the plant absorb them through the openings in the leaves or stomata or through the cell walls and membranes to participate directly in the vital processes of the plant [13]. It is one of the commonly used methods to treat problems of deficiency of nutrients (micro and macro) and is used in regulating traditional production [14]. The response of fruit trees to foliar feeding varies depending on the concentration of the element to be added, the nature of the fertilizer, the number of sprays, the time of addition of the fertilizer, and the type of fruit. Despite the advantages of foliar feeding, it is not a substitute for ground fertilization, but rather a complement to it

[15 and 16]. Note that the plant's need for trace mineral elements is small and their fixing factors are many and varied. Therefore, adding them by spraying at the appropriate time, twice or once, to meet the plant's needs is the correct method [17]. Calcium is an essential element for the processes of growth and cell division, as it plays a fundamental role in the permeability of plasma membranes through its role in transmitting signals within the plant. In addition, it works to increase the plant's ability to absorb and benefit from many nutrients and to increase the metabolism of carbon dioxide, thus increasing the cells' tolerance to water, environmental and thermal stress and their resistance to insect and fungal infections. It also plays an important role

2-Material and Methods

Prepare samples:

The experiment was conducted in a private orchard located at latitude 35.69° and longitude 44.31° during the 2024 growing season in Al-Tun Kibrr sub-district, Al-Dabes district. The vines were of the Zaytouni grape variety, trained using the overhead trellis system, with a spacing of 2*4 m, planted in rows running east to west, and were 14 years old. As much as possible, 81 vines of similar size were selected to study the effect of fruit thinning and foliar application of salicylic acid, nano-calcium, and boron on the quality traits of Zaytouni grapes. Winter pruning was carried out in the second week of February, leaving (5) fruiting canes on the vine, with (12) eyes and (5) fruiting spur

with a length of (6) eyes. In February, 5 kg of composted sheep manure (animal manure) was applied to each vine, along with 250 g of DAP fertilizer (0-46-18)

in activating enzymes [18 and 19]. Boron has catalytic metabolic roles such as lipid, phosphorus and nitrogen metabolism, and regulates the activity of plant hormones, photosynthesis and active transport, and has an auxiliary role in stimulating the formation of phenolic compounds, and as a component of the root cell membrane, where it affects the ATPase enzyme present in the membranes, which transports and moves sulphate, chloride and phosphate ions in the root tissues under boron deficiency conditions [20]. This study aims to: know the effect of the studied factors in improving the qualitative characteristics of Zaytouni grape fruits.

Jordanian origin per vine, applied in two applications: the first at bud break and the second at the beginning of flowering. A preventive spray of a systemic fungicide was applied to control powdery mildew and downy mildew. Routine orchard operations, including, weeding and cleaning the field of weeds, organizing the basins and irrigation, were performed as needed during the growing season. Random soil samples were collected from several locations in an X-shaped pattern to a depth of 0-60 cm for soil analysis. The sample was analyzed at the Kirkuk Directorate of Agriculture laboratory, and several physical and chemical properties were determined. This is shown in Table 1

Table 1. Some physical and chemical properties of orchard soil

Testing	Values	Units
Nitrogen available (N)	20.73	mg kg ⁻¹
Phosphorus available (P)	79.4	mg kg ⁻¹
Potassium available (K)	335.28	mg kg ⁻¹
EC	0.44	dS.m

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pH	7.92	
Tissue	loamy	
Caly	12	%
Silt	40	%
Sand	48	%

2.1 Factors studied:

1- first factor: Fruit thinning: Thinning was performed when the grape bunches had reached full development.

Level 1: control without thinning (A1)

Level 2: Complete thinning (A2)

Level 3: Partial thinning(A3)

2- Second factor: Foliar application of salicylic acid: During the growing season, the vines were sprayed with salicylic acid at three concentrations (0, 75, and 150 mg/L⁻¹) and three application dates, starting from May 1st to July 1st, 2024 (with one-month intervals between applications). Tween 20 (0.1%) was added as a surfactant. A 20-liter sprayer was used, and the vines were sprayed thoroughly until dripping in the early morning

3- third factor: Foliar application of nano-calcium oxide and boron: In the morning, the vines were sprayed with nano-calcium oxide (CaO) as a source of calcium at a concentration of 150 mg Ca/L⁻¹. Two days later, the vines were treated with boric acid (H3BO3) containing 17% boron as a source of boron at a concentration of 45 mg/L⁻¹. The vines were sprayed twice (at the beginning of flowering and after fruit set)

C1: (zero as a control treatment)

C2: (45 mg L⁻¹) of boron.

C3: (150 mg Ca L⁻¹) of calcium.

2.2 Study Indicators:

1. Cluster Length (cm): This was calculated by randomly selecting five

clusters for each treatment and calculating their length using an electronic Vernier caliper. The average was then extracted.

2. Cluster Diameter (cm): This was calculated by selecting the same clusters used to calculate cluster length and calculating their diameter from the widest area using an electronic Vernier caliper. The average was then extracted.

3. Estimation of Total soluble Solids (TSS) %: This percentage was calculated using a digital refractometer. This was done by placing 1-2 drops of clear juice on the surface of a bottle and recording the reading immediately. The device was pre-zeroed with distilled water before each reading.

4 - Estimating the percentage of total sugars in the juice%:

According to Method [21], this percentage was estimated by adding 1 ml of phenol with a concentration of 5% and 5 ml of concentrated sulfuric acid to 1 ml of juice with continuous shaking. The mixture was then left to cool and the light absorption was read using a spectrophotometer at a wavelength of 490 nm. The readings were then plotted on a glucose measurement curve. The concentration of total sugars was estimated as a percentage in the juice according to the following equation:

Total Sugars % =

$$\left(\frac{\text{Concentration Curve Standard} \times \text{Dilution}}{\text{Juice Volume Taken}} \right) \times 1000$$

5 - Estimating the total acidity in the juice: (Total Acidity T.A.) %

The acidity was calculated by titration with (NaOH) sodium hydroxide with a molarity of (0.1) in the presence of the indicator reagent (phenolphthalein). The acidity was estimated based on tartaric acid as the acid. Prevalent in grapes according to [22].

Total acidity % =

$$\begin{aligned} & (\text{Volume of base} \times \text{Its titer}(0.1) \\ & \times \text{weight Equivalent of acid} \\ & \times \text{Dilution} \times 100) \\ & / ((\text{sample volume} \times 1000)) \end{aligned}$$

6- Anthocyanin pigment (mg/100 ml⁻¹ of juice): Anthocyanin pigment was determined by taking 5 ml of clear juice and placing it in a 10 ml test tube. 5 ml of the extraction solution (95% ethanol and 1.5 N hydrochloric acid) was added to it, at a ratio of 15.85 for each, respectively. The solution was then centrifuged for 3 minutes at 3000 rpm⁻¹. The precipitate was removed, and the filtrate was taken and made up to 10 ml with the extraction solution (acidified alcohol). The absorption of light at a wavelength of 535 nm was read using a spectrophotometer according to [23] according to the following equation:

$$\begin{aligned} \text{Content anthocyanin (mg 100 ml}^{-1}) &= \\ & (\text{reading instrument} \times \text{volume solution}) / \\ & (\text{volume sample} \times 98.2) \times \text{dilution} \times 100 \end{aligned}$$

Experimental Design and Statistical Analysis: The experiment was conducted as a factorial split-plot experiment, according to the Randomized Complete Block Design (RCBD) with three factors (fruit thinning, salicylic acid spray, nano-calcium, and boron). Twenty-seven treatments were generated from the various interactions of the study factors. The treatments were randomly distributed into three replicates, comprising 81 experimental units, each representing one vine. Data were statistically analysed after collecting the data according to the design used using SAS software, and means were compared using Duncan's multiple range test at a probability level of 0.05 [24].

3. Results and Discussion

3.1. Cluster Length (cm)

The results of the statistical analysis in Table 2: show significant differences in cluster length with respect to the effect of fruit thinning. The (total thinning) treatment significantly excelled on the (partial thinning) treatment, with the highest value of 21.71 cm, compared to the (partial thinning) treatment, with the lowest value of 15.56 cm. The same table shows that spraying with salicylic acid did not produce significant differences between the levels studied. The same table also shows no significant differences in cluster length with respect to spraying with nano-calcium and boron at all levels. Regarding bi-interaction between the effect of fruit thinning and spraying with salicylic acid, significant differences were observed, as the interaction treatment (total thinning) and the interaction treatment (150 mg L⁻¹) were significantly excelled in recording the highest value of 24.33 cm compared to the interaction treatments (partial thinning) with treatments (without spraying), (75 mg L⁻¹) and (150 mg L⁻¹), which recorded the lowest values of 14.82, 15.32 and 16.53 cm, respectively. The same applies to bi-interaction between the effect of fruit thinning and spraying nano-calcium and boron, which yielded significant differences. The interaction treatment (total thinning) and the interaction treatment (150 mg L⁻¹ of nano-calcium) were significantly excelled, recording the highest value of 22.46 cm compared to the interaction treatment (partial thinning) with each of the treatment (without spraying), treatment (45 mg L⁻¹ of boron), and treatment (150 mg L⁻¹ of nano-calcium), which recorded the lowest values of 15.28, 15.65, and 15.75 cm, respectively. As for bi- interaction between salicylic acid and spraying nano-calcium and boron, we note that there were no significant differences between the treatments. While triple interaction between the effects of fruit thinning, salicylic acid spraying, and nano-calcium and boron spraying indicate significant differences between treatments,

we note a significant increase in triple interaction treatments (total thinning), (150 mg L⁻¹), and (150 mg L⁻¹ of nano-calcium), recording the highest value of 25.17 cm,

compared to (partial thinning), (no spraying), and (water spraying), which recorded the lowest value of 14.13 cm.

Table 2. Effect of fruit thinning, salicylic acid spraying, nano-calcium, and boron, and their interactions on cluster length (cm).

Fruit Thinning	Salicylic acid	Nano calcium and boron			Interaction between (A and B)	Effect of Fruit thinning
		C1	C2	C3		
without thinning	B1	20.25 b-	20.32 b-d			19.93 b
	B2	d 21.46	18.83 c-e			
	B3	a-c	19.65 b-e			
A1	B1	19.29 c-e	20.27 b-d	20.74 a-d	20.43 b	21.71 a
	B2	19.89 b-	22.29 a-c	19.14 c-e	19.81 b	
	B3	e	24.35 ab	19.75 b-e	19.56 b	
Total thinning	B1	20.82 a-	15.14 ef	20.75 a-d	21.83 b	15.56 c
	B2	d 23.46	15.29 ef	23.18 a-c	24.33 a	
	B3	a-c	16.52 d-f	25.17 a	14.82 c	
Partial thinning		14.13 f	C2	15.21 ef	15.32 c	16.53 c
	A1	15.26 ef	19.60 b	15.42 ef	16.63 d-f	
	A2	16.45 d-f	21.85 ab	16.63 d-f		
A3	A3	C1	15.65 c	C3	The effect of salicylic acid	
		20.33 ab	C2	19.87 b		
		20.98 ab		22.46 a		
Interaction between (A and C)		15.28 c		15.75 c		
		C1		C3		
Interaction between (B and C)	B1	18.88 a	19.26 a	19.63 a	19.26 a	
	B2	19.97 a	19.19 a	19.22 a	19.49 a	
	B3	19.62 a	20.04 a	20.32 a	19.99 a	
Effect of Nano calcium and boron		19.48 a	19.47 a	19.72 a		

*Means with similar letters for each individual factor and their interactions are not significantly different according to Duncan's multiple range test at the 0.05 probability level.

3.2. cluster diameter (cm)

The results of Table 3: indicate significant differences in cluster diameter with respect to the effect of fruit thinning. The (partial thinning) treatment significantly excelled on the (no thinning) treatment, with the

highest value of 15.45 cm, compared to the (no thinning) treatment, with the lowest value of 13.19 cm. The same table shows that spraying with salicylic acid caused significant differences between treatments, as a significant increase in (150 mg L⁻¹)

was observed with a value of 14.39 cm compared to the control treatment, which recorded the lowest value of 14.03 cm. The same table also shows no significant differences in cluster diameter with respect to spraying nano-calcium and boron at all levels. Regarding bi- interaction between the effect of fruit thinning and spraying with salicylic acid, significant differences were observed, as the (partial thinning) interaction significantly excelled the (partial thinning) treatment. Interaction treatment (150 mg L⁻¹) recorded the highest value of 15.78 cm, compared to interaction treatments (without thinning) and (without spraying), which recorded the lowest value of 12.84 cm .As for bi-interaction between the effects of fruit thinning and nano-calcium and boron spraying, which yielded significant differences, most of the interaction treatments were significantly excelled, most notably interaction treatment (partial thinning) and interaction treatment (150 mg L⁻¹ of nano-calcium), recording the

highest value of 15.59 cm, compared to several interaction treatments, most notably control treatments (without thinning) and (without spraying), which recorded the lowest value of 13.09 cm. As for bi- interaction between salicylic acid and nano-calcium and boron spraying, we note no significant differences between the treatments. As for triple interaction between the effects of fruit thinning, salicylic acid spraying, and spraying Nano-calcium and boron indicate significant differences between treatments. Significant increases were found for several treatments, most notably the triple-interaction treatment (partial thinning), the interaction treatment (150 mg L⁻¹), and the interaction treatment (150 mg L⁻¹ of nano-calcium), which recorded the highest value of 15.92 cm, compared to the interaction treatment (without thinning), the comparison treatment (without spraying), and the comparison treatment (water spraying), which recorded the lowest value of 12.73 cm.

Table 3. Effect of fruit thinning and spraying with salicylic acid, nano-calcium, and boron, and their interactions, on cluster diameter (cm)

Fruit Thinning	Salicylic acid	Nano calcium and boron			Interaction between (A and B)	Effect of Fruit thinning
		C1	C2	C3		
without thinning A1	B1	12.73 i	12.84 hi	12.97 g-i	12.84 g	13.19 c
	B2	13.12 f-i	13.23 e-i	13.36 d-i	13.24 f	
	B3	13.43 d-i	13.50 d-i	13.57 b-	13.50 e	
Total thinning A2	B1	14.59 a-	14.68 a-g	h 14.75	14.67 d	14.70 b
	B2	h	14.55 a-h	a-g 14.61	14.69 d	
	B3	14.85 a-f	14.77 a-g	a-h	14.78 d	
Partial thinning A3	B1	14.70 a-	15.14 a-d	14.87 a-f	15.12 c	15.45 a
	B2	g	14.44 a	15.26 a-c	15.46 b	
	B3	14.95 a-e	15.75 a	15.58 a	15.78 a	
Interaction between (A and C)		15.36 ab	C2	15.92 a	The effect of salicylic acid	
	A1	15.67 a	13.19 b	C3		
	A2	C1	14.65 a	13.30 b		
	A3	13.09 b	15.44 a	14.75 a		
		14.71 a	C2	15.59 a		
	15.33 a	C1	C3			

Interaction between (B and C)	B1	13.91 a	14.04 a	14.14 a	14.03 c
	B2	14.26 a	14.16 a	14.22 a	14.21 b
	B3	14.31 a	14.38 a	14.48 a	14.39 a
Effect of Nano calcium and boron		14.15 a	14.18 a	14.27 a	

*Means with similar letters for each individual factor and their interactions are not significantly different according to Duncan's multiple range test at the 0.05 probability level.

3.3. Estimating the percentage of total soluble solids (TSS)

The results of Table 4: indicate significant differences in the percentage of total soluble solids with respect to the effect of fruit thinning. The two fruit thinning treatments, (total thinning) and (partial thinning), significantly excelled the (no thinning) treatment, with the highest value of 16.63 and 16.51% compared to the (no thinning) treatment with the lowest value of 15.05%.

The same table shows that spraying with salicylic acid did not produce significant differences between the studied levels. The same table also shows that there were no significant differences in the same characteristic with regard to spraying nano calcium and boron for all levels. As for bi-interaction between the effect of fruit thinning and spraying with salicylic acid, significant differences were observed, as the interaction treatment (total thinning) and the interaction treatment (150 mg L⁻¹) were significantly excelled in recording a value of 17.12% compared to the interaction treatments (without thinning) with treatments (without spraying), (75 mg L⁻¹) and (150 mg L⁻¹), which recorded the lowest values of 14.82, 15.12 and 15.21%, respectively. The same applies to bi-interaction between the effect of fruit thinning and spraying nano-calcium and boron, which yielded significant differences. Most treatments outperformed significantly, the most prominent of which were the interaction treatment (total

thinning) and the interaction treatment (150 mg L⁻¹ of nano-calcium), recording the highest value of 16.83% compared to the interaction treatment (without thinning) with each of the treatment (without spraying), the treatment (45 mg L⁻¹ of boron) and the treatment (150 mg L⁻¹ of nano-calcium), which recorded the lowest values of 14.89, 15.14 and 15.14%, respectively. As for bi-interaction between salicylic acid and spraying nano-calcium and boron, we note that there were no significant differences between the treatments. While the triple interaction between the effect of fruit thinning treatment, salicylic acid spraying treatment, and nano calcium and boron spraying treatment indicates the presence of significant differences between treatments, as we note the presence of a significant increase in the interaction treatments, most notably the triple interaction treatments (total thinning), (75 mg L⁻¹), and (without spraying), the triple interaction treatment (total thinning), (150 mg L⁻¹), and (150 mg L⁻¹ of nano calcium), and the triple interaction treatment (partial thinning), (150 mg L⁻¹), and (150 mg L⁻¹ of nano calcium), recording the highest values of 17.21, 17.25, and 17.33% compared to the interaction treatment (without thinning), the comparison treatment (without spraying), and the comparison treatment (spraying with water), which recorded the lowest value of 14.71%.

Table 4. Effect of fruit thinning, spraying with salicylic acid, nano-calcium, and boron, and their interactions on the percentage of total soluble solids (TSS) (%).

Fruit Thinning	Salicylic acid	Nano calcium and boron			Interaction between (A and B)	Effect of Fruit thinning
		C1	C2	C3		
without thinning A1	B1	14.71 e	14.80 de	14.96 ed	14.82 c	15.05 b
	B2	15.01 c-e	15.13 c-e	15.24 b-e	15.12 c	
	B3	14.95 de	15.48 a-e	15.22 b-e	15.21 c	
Total thinning A2	B1	16.08 a-e	15.69 a-e	16.59 a-e	16.12 b	16.63 a
	B2	17.21 a	16.73 a-d	16.92 a-c	16.98 ab	
	B3	16.96 a-c	17.14 ab	17.25 a	17.12 a	
Partial thinning A3	B1	16.25 a-e	16.65 a-e	16.00 a-e	16.30 ab	16.51 a
	B2	16.26 a-e	16.56 a-e	16.62 a-e	16.48 ab	
	B3	16.50 a-e	16.48 a-e	17.33 a	16.77 ab	
Interaction between (A and C)		C1	C2	C3	The effect of salicylic acid	
	A1	14.89 b	15.14 b	15.14 b		
	A2	16.71 a	16.35 a	16.83 a		
Interaction between (B and C)		C1	C2	C3		
	B1	15.57 a	15.52 a	15.82 a	15.64 a	
	B2	16.14 a	15.98 a	16.00 a	16.04 a	
Effect of Nano calcium and boron						
		15.85 a	15.86 a	16.01 a		
					16.08 a	

*Means with similar letters for each individual factor and their interactions are not significantly different according to Duncan's multiple range test at the 0.05 probability level.

3.4. Estimation of the percentage of total sugars in the juice (%)

The results of the statistical analysis in Table 5: show significant differences in the percentage of total sugars in the juice. Treatment (complete thinning) significantly excelled the two control treatments, (without thinning) and (partial thinning), with the highest value of 14.44% compared to the with the lowest values of 12.53 and 12.78%, respectively. The same table indicates that spraying with salicylic acid caused significant differences in the studied trait, as treatment (150 mg L⁻¹) was

significantly excelled with the highest value of 13.50% compared to the comparison treatment, which reached the lowest value of 12.92%. The same table explains that spraying with nano-calcium and boron did not observe any significant differences between the levels. Bi-interaction between the effect of fruit thinning and spraying with salicylic acid showed significant differences between the interaction treatments, as the interaction treatment (total thinning) and (150 mg L⁻¹) significantly excelled with the highest value of 15.47% compared to the interaction treatments (without thinning)

for treatments (75 mg L^{-1}) and (150 mg L^{-1}) and the interaction treatment (partial thinning) and (without spraying) with the lowest values of 11.96, 11.91 and 12.22% respectively. Bi- interaction between the effect of fruit thinning and nano-calcium and boron spraying also showed significant differences between treatments. It showed a significantly excelled for the interaction treatments (total thinning) over treatments (no spraying), (45 mg L^{-1} of boron), and (150 mg L^{-1} of nano-calcium), recording the highest values of 14.28, 14.46, and 14.63%, respectively, compared to the interaction treatments (no thinning) and (150 mg L^{-1} of nano-calcium), which recorded the lowest value of 12.04%. As for bi- interaction between salicylic acid and nano-calcium and boron spraying, we note significant differences between the treatments. Interaction treatments (150 mg L^{-1}) and (45 mg L^{-1} of boron) recorded a significantly excelled, with the highest

value reaching 13.84% compared to the two intervention treatments (without spray) and (45 mg L^{-1} of boron) and the intervention treatment (without spray) and (150 mg L^{-1} of nano calcium) which recorded the lowest values of 12.81 and 12.79% respectively. Triple interaction between the effect of fruit thinning, salicylic acid spraying, and nano-calcium and boron spraying indicates significant differences between treatments. Significant differences were observed for triple interaction treatment (total thinning), (150 mg L^{-1}), and (150 mg L^{-1} of nano-calcium), which recorded the highest value of 15.63% compared to the two interaction treatments (without thinning), (75 mg L^{-1}), and (45 mg L^{-1} of boron), and the interaction treatment (without thinning), (75 mg L^{-1}), and (150 mg L^{-1} of nano-calcium), which recorded the lowest values of 11.65 and 11.74%, respectively.

Table 5. The effect of fruit thinning and spraying with salicylic acid, nano calcium, and boron and their interactions on the percentage of total sugars in the juice (%)

Fruit Thinning g	Salicylic acid	Nano calcium and boron			Interaction between (A and B)	Effect of Fruit thinning g
		C1	C2	C3		
without thinning A1	B1	14.18 a-	14.58 a-d	12.37 e-i	13.71 cd	12.53 b
	B2	d 12.49	11.65 i	11.74 i	11.96 f	
	B3	e-i 11.83	11.92 hi	12.00 hi	11.91 f	
Total thinning A2	B1	hi 13.80	13.90 b-e	14.12 a-d	13.94	14.44 a
	B2	c-f	14.54 a-d	14.64 a-d	c 14.42 b	
	B3	14.23 a-	15.44 ab	15.63 a	15.47 a	
Partial thinning A3	B1	d 14.34	12.24 f-i	12.33 e-i	12.22 f	12.78 b
	B2	a-c	12.54 e-i	13.06 d-i	12.68 e	
	B3	12.10 g-i	13.45 d-h	13.65 d-	13.42 d	
		12.44 e-i	C2	g		
	A1	13.17 d-i	12.71 bc	C3	The effect of salicylic	
	A2	C1	14.46 a	12.04 c		
	A3	12.83 bc	12.74 bc	14.63 a		

Interaction between (A and C)		14.28 a	C2	13.01 b	acid
		12.57 bc	C1	C3	
Interaction between (B and C)	B1	13.18 ab	12.81 b	12.79 b	12.92 c
	B2	13.04 ab	13.18 ab	13.32 ab	13.18 b
	B3	13.61 ab	13.84 a	13.06 ab	13.50 a
Effect of Nano calcium and boron		13.29 a	13.30 a	a 13.06	

* Means with similar letters for each individual factor and their interactions are not significantly different according to Duncan's multiple range test at the 0.05 probability level.

3.5. Estimation of Total Acidity in Juice (TA) (%)

The results of Table 6: indicate significant differences in the total acidity of juice. The fruit thinning effect treatment (without thinning) significantly excelled, recording the highest value of 0.462%, compared to the study treatments (total thinning) and (partial thinning), which recorded the lowest values of 0.332% and 0.375%, respectively. The same table indicates that spraying with salicylic acid did not produce significant differences between levels for the same trait studied. The same table explains that spraying with nano-calcium and boron did not show significant differences between levels. Bi- interaction between the effect of fruit thinning and spraying with salicylic acid shows significant differences between treatments, as significantly excelled was observed for bi- interaction treatments (without thinning) with each of treatment (without spraying), treatment (75 mg L⁻¹) and treatment (150 mg L⁻¹) by recording the highest values of 0.465, 0.465 and 0.457% respectively compared to the interaction treatment. (total thinning) and (150 mg L⁻¹)

recorded the lowest value of 0.300%. Bi- interaction between the effect of fruit thinning and spraying nano-calcium and boron also showed significant differences between treatments, as it showed a significantly excelled of bi- interaction treatments (without thinning) with each of treatment (water spraying), treatment (45 mg L⁻¹ of boron) and treatment (150 mg L⁻¹ of nano-calcium), recording the highest values of 0.462, 0.466 and 0.459%, respectively, compared to the other treatments. As for bi- interaction between salicylic acid and spraying nano-calcium and boron, we note that there are no significant differences between the treatments. Triple interaction between the effects of fruit thinning, salicylic acid spraying, and nano-calcium and boron spraying revealed significant differences between the treatments. Triple interaction between treatments (without thinning), (75 mg L⁻¹), and (45 mg L⁻¹ of boron) showed significantly excelled, recording the highest value of 0.475% compared to several other three-way interaction treatments.

Table 6. Effect of fruit thinning, salicylic acid spraying, nano-calcium, and boron, and their interactions on the total acidity of the juice (%).

Fruit Thinning	Salicylic acid	Nano calcium and boron			Interaction between (A and B)	Effect of Fruit thinning
		C1	C2	C3		
without thinning A1	B1	0.472 ab	0.466 a-c	0.456 a-d	0.465 a	0.462 a
	B2	0.451 a-e	0.475 a	0.469 ab	0.465 a	
	B3	0.464 a-c	0.457 a-d	0.451 a-e	0.457 a	
Total thinning A2	B1	0.353 d-f	0.349 d-f	0.343 ef	0.348 de	0.332 b
	B2	0.338 f	0.327 f	0.320 f	0.330 e	
	B3	0.313 f	0.297 f	0.291 f	0.300 f	
Partial thinning A3	B1	0.397 a-f	0.393 a-f	0.387 a-f	0.392 b	0.375 b
	B2	0.382 a-f	0.375 a-f	0.368 a-f	0.375 bc	
	B3	0.363 b-f	0.357 c-f	0.352 d-f	0.357 bc	
Interaction between (A and C)	C1		C2	C3	The effect of salicylic acid	
	A1	0.462 a	0.466 a	0.459 a		
	A2	0.339 b	0.330 b	0.324 b		
Interaction between (B and C)	C1		C2	C3		
	B1	0.409 a	0.404 a	0.397 a	0.404 a	
	B2	0.392 a	0.403 a	0.406 a	0.400 a	
Effect of Nano calcium and boron	B3	0.401 a	0.392 a	0.386 a	0.393 a	
		0.401 a	0.400 a	0.396 a		

*Means with similar letters for each individual factor and their interactions are not significantly different according to Duncan's multiple range test at the 0.05 probability level.

3.6. Anthocyanin Pigment (mg/100 ml⁻¹ of juice)

The results of Table 7: indicate significant differences in anthocyanin pigmentation with respect to the effect of fruit thinning. The (total thinning) treatment significantly excelled the (no thinning) treatment, with the highest value of 0.958 mg/100 ml⁻¹, compared to the (no thinning) treatment, with the lowest value of 0.660 mg/100 ml⁻¹. The same table shows that spraying with salicylic acid did not produce significant differences between the levels studied. The same table also shows that there were no significant differences in the same characteristic with regard to spraying nano

calcium and boron for all levels. As for bi-interaction between the effect of fruit thinning and spraying with salicylic acid, significant differences were observed, as the interaction treatment (total thinning) and the interaction treatment (75 mg L⁻¹) were significantly excelled in recording a value of 1.077 mg 100 ml⁻¹ compared to the interaction treatment (without thinning) and (75 mg L⁻¹), which recorded the lowest value of 0.587 mg 100 ml⁻¹. The same applies to bi- interaction between the effect of fruit thinning and spraying nano-calcium and boron, which gave significant differences. Most treatments were significantly excelled, and the most

prominent of them were the interaction treatment (total thinning) and the interaction treatment (45 mg L⁻¹ of boron), which recorded the highest value of 1.042 mg 100 ml⁻¹ compared to the interaction treatment (without thinning) with each of the treatment (without spraying), the treatment (45 mg L⁻¹ of boron), and the treatment (150 mg L⁻¹ of nano-calcium), which recorded the lowest values of 0.644, 0.660, and 0.676 mg 100 ml⁻¹, respectively. As for the dual interaction between salicylic acid and nano calcium and boron spraying, we note the presence of significant differences between their treatments, as they caused significantly excelled for the interaction treatment (150 mg L⁻¹) and (45 mg L⁻¹ of boron) with the highest value reaching 0.868 mg 100 ml⁻¹ compared to the interaction treatment (without spraying) and (spraying with water) which recorded the lowest value reaching 0.660 mg 100 ml⁻¹. While the triple interaction between the effect of the fruit thinning treatment, the salicylic acid

spraying treatment, and the nano calcium and boron spraying treatment indicates the presence of significant differences between the treatments, as we note the presence of a significant increase in the interaction treatments, most notably the triple interaction treatments (total thinning), (75 mg L⁻¹), and (45 mg L⁻¹ of boron), the triple interaction treatment (total thinning), (75 mg L⁻¹), and (150 mg L⁻¹ of nano calcium), the triple interaction treatment (total thinning), (150 mg L⁻¹), and (spraying with water), and the triple interaction treatment (total thinning), (150 mg L⁻¹), and (45 mg L⁻¹ of boron), recording the highest values of 1.121, 1.124, and 1.134 and 1.146 mg/100 ml⁻¹ compared to the two interaction treatments (without thinning), (75 mg/L⁻¹), and (water spraying). The interaction treatments (without thinning), (75 mg/L⁻¹), and (45 mg/L⁻¹ of boron) recorded the lowest values, reaching 0.585 and 0.567 mg/100 ml⁻¹.

Table 7. Effect of fruit thinning, spraying with salicylic acid, nano-calcium, and boron, and their interactions, on the anthocyanin content of the juice (mg/100 ml⁻¹)

Fruit Thinning g	Salicylic acid	Nano calcium and boron			Interaction between (A and B)	Effect of Fruit thinning g
		C1	C2	C3		
without thinning A1	B1	0.683 c-f	0.694 c-f	0.701 c-f	0.693 de	0.660 b
	B2	0.585 f	0.567 f	0.611 ef	0.587 e	
	B3	0.665 d-e	0.719 c-f	0.716 c-f	0.700 de	
Total thinning A2	B1	0.663 e	0.930 a-d	0.969 a-c	0.854 bc	0.958 a
	B2	d-f	1.121 a	1.124 a	1.077 a	
	B3	1.021 ab	1.146 a	0.680 c-f	0.986 ab	
Partial thinning A3	B1	1.134 a	0.727 c-f	0.775 b-f	0.703 de	0.806 ab
	B2	0.606 ef	0.880 a-e	0.882 a-e	0.881 bc	
	B3	0.881 a-e	0.888 a-e	0.730 c-f	0.834 cd	
Interaction n		0.885 a-e	C2	C3	The effect of salicylic acid	
	A1	C1	0.660 c	0.676 c		
	A2	0.644 c	1.042 a	0.935 ab		
	A3	0.900 ab	0.831 b	0.796 bc		
		0.790 bc	C2	C3		
		C1				

between (A and C.)					
Interactio n between (B and C)	B1	0.660 c	0.795 a-c		
	B2	0.818 ab	0.821 ab	0.823 ab	0.759 a
	B3	0.837 ab	0.868 a	0.807 ab	0.816 a
				0.710 bc	0.805 a
Effect of Nano calcium and boron					
		0.767 a	0.825 a	0.783a	

*Means with similar letters for each individual factor and their interactions are not significantly different according to Duncan's multiple range test at the 0.05 probability level.

The results of Tables 4, 5, 6, and 7: indicate an increase in chemical properties resulting from the effects of thinning and salicylic acid. Using fruit thinning to reduce cluster firmness led to a greater increase in the total sugar content of the juice Table 5: and the anthocyanin content of the juice Table 7 : [25]. The increase in these sugars in the juice is due to the increased activity of cell wall invertase (CWI), which is a major regulator of carbon distribution during grape ripening [26]. This may be attributed to the fact that the cluster thinning process has shown a consistent effect on the chemical composition of the fruit. The chemical composition of the fruit can change so that it has a higher ratio of sugars to acids, and as a result, the fruit tends to taste sweet [27; 28 and 29]. This is what was observed in the estimation of the percentage of total soluble solids Table 4 : and the percentage of total sugars in the juice Table 5. The results are consistent with what was reached by [30] in their study conducted to determine the effect of cluster thinning on the quality of the cluster of two grape varieties (Roomy Red and Ruby Seedless). It agreed with what [31] stated in their study to know the effect of manual thinning of fruits on the quality of the local

mandarin fruit crop, and it agreed with what [32] reached to know the effect of thinning and foliar spraying with some fertilizers on the qualitative characteristics and mineral content of apple fruits of the (Golden Delicious) variety. It agreed with what [33] reached to know the effect of cluster thinning and foliar application using earthworm fertilizer and humic acid on (Ruby Seedless) grape vines. As for salicylic acid, it may be due to its mechanical action, as salicylic acid improves membrane permeability, which facilitates the absorption and utilization of mineral nutrients. This also contributes to increasing the ability of plants treated with spraying to produce biomass, which is reflected in the increase in the fresh and dry weight of plants, and thus an increase in the percentage of total sugars in the juice Table 5 and the contents of other chemical substances [34]. The reason for the increase in chemical properties may be due to the vegetative growth characteristics, as salicylic acid may be the reason for the increase in the leaf area of the vine and thus an increase in manufactured carbohydrates, which is reflected in improving the qualitative characteristics of grape fruits, especially the percentage of total soluble solids [35].

Salicylic acid was found to significantly increase the levels of anthocyanin pigment Table 7: possibly due to its effect on the expression of phenylalanine ammonia-lyase (PAL) activity and other enzymes involved in the biosynthesis of these metabolites. PAL activity was mainly focused on the production of anthocyanins more than other phenols. Therefore, increasing PAL activity leads to an increase in anthocyanins [36]. The results were consistent with what [37] concluded

4. Conclusions

Based on the results obtained, the following conclusions can be drawn:

1- The thinning factor significantly increased the following traits: cluster length, cluster diameter, TSS, percentage of total sugars, percentage of total acidity, and fruit anthocyanin content.

regarding the effect of spraying salicylic acid on Kesar mango trees. They were consistent with what [38] stated in his study on the effect of spraying salicylic acid and nitrogen on the growth and yield of Kamali grapes. They were consistent with what [39] stated in a study to determine the effect of foliar spraying with salicylic acid on some qualitative traits of Royal apricot trees. From the achieved results.

2- The salicylic acid factor had a significant effect on each of the following traits: cluster diameter and percentage of total sugars in the fruit.

3- As for calcium and boron, no significant differences were recorded in the studied traits.

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