Effect of Spraying Sugar Alcohols and Amino Acids on Some Characteristics of Vegetative Growth and Yield of "Halwani" Grapevines

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Abstract

Study conducted on Halwani grape vines to study the effect of spraying with sugar alcohol (mannitol) and amino acids at three concentrations of each (0, 5, and 10 ml L^{-1}) on some vegetative growth characteristics, yield, and quality, vines were sprayed three times during the season: the first spray at the beginning of vegetative growth, the second before the flowers bloomed, and the last spray after the fruit set. Spraying with 5 and 10 ml L^{-1} of sugar alcohol significantly increased the leaf area of vines, leaf chlorophyll content, average number of clusters, and yield per hectare, total soluble solids and anthocyanin content of fruits. The acidity of berry decreased and the average weight of clusters, vine yield and total sugars significantly increased at a concentration of 10 ml L^{-1}, reached 0.308%, 529.87 g, 16.55 kg $vine^{-1}$ and 13.630%, respectively. While spraying with a concentration of 5 and 10 ml L^{-1} of amino acid led to a significant increase in the leaf area of vines, average number and weight of the clusters, percentage of TSS and anthocyanin content of the fruits, the concentration of 5 and 10 ml L^{-1} significantly affected the chlorophyll content of leaves, vine yield, yield per hectare and total sugar content in fruits, and the acidity content in fruits decreased significantly and reached 0.304% compared to the rest of the concentrations. The interaction between the study factors had a clear significant effect in improving the vegetative characteristics and the quantitative and qualitative qualities of the yield.

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Introduction

The genus Vitis is one of 14 genera of the Vitaceae family, which includes the European grape *Vitis vinifera* L. it was first cultivated in Central Asia and the area between the southern Black Sea and the Caspian Sea, it is widely distributed in subtropical and temperate regions, the best cultivation area is between 34 and 45 degrees north latitude and between 31 and 38 degrees south latitude (Al-Saeedi, 2000). Grapes have many useful types and varieties of fruit, peel, pulp and seeds, which have a laxative effect on the intestines and reduces the incidence of heart, liver and colon diseases due to their special anti-inflammatory properties. Its juice has many benefits as it helps dissolve kidney stones and sand treats diarrhea and lung diseases (Al-Mawsili, 2012). The Halwani cultivar is one of the luxurious table grape varieties in terms of production. It is a late-ripening, its characterized by its conical, elongated clusters with one large shoulder and spherical berries that are red, dark purple or violet in color, with a thin skin and astringent fleshy pulp (Al-Saeedi, 2000).

Sugar alcohols are simple organic compounds that occur naturally in plants and are one of the most important products of photosynthesis, they represent a new generation of foliar nutrients because they are rapidly absorbed, easily transported, and can be moved from source to sink via the phloem, there is no doubt that the cuticle layer is the main determinant of the success of the foliar spraying process, as the sugar alcohols work to penetrate the nutrients through this layer into the spaces between the leaf cells and on the other hand through the stomata present in the cuticle layer because the molecular size of the sugar alcohol is very small, so it can pass easily (Brown and Hu, 1996). Sugar alcohols are important natural nutrients for plants because they promote leaf absorption, they can prolog the time it takes for leaves to absorb micronutrients, especially boron, before the leaf surface dries, in addition to its role in regulating the osmotic pressure of plants of the Rosaceae family when they accumulate inside the plants, which leads to improving the plant's of water and nutrients from the soil for use in increasing vegetative growth (Niu *et al*., 2020). In this regard, Khazraji and Al-Douri (2025) showed in their study the effect of spraying with sugar alcohol mannitol on grape vines of Halwani and Kamali cultivars that spraying at a concentration of 8 ml L^{-1} led to a significant increase in the number and weight of the cluster, vine yield and the content of sugars and anthocyanins in the fruits compared to the concentration of 0 and 4 ml L^{-1}.

Amino acids are carboxylic acids containing one or more amino groups. The basic building blocks of proteins are α-amino acids, in which the amino group is bonded to the α-carbon atom (i.e., the atom adjacent to the carboxyl group) (Al-Dawudi, 1990). Spraying plants with amino acids is an effective way to provide readily available protein building blocks and can directly or indirectly affect plant physiological activities, including resistance to high or low temperatures, high humidity, insect infestation, and high salinity. It also influences photosynthesis and promotes chlorophyll formation, thereby increasing photosynthesis efficiency. Amino acid concentrations in plants also affect stomatal opening and closing, as some amino acids act as osmolytes in guard cells (Abd El-Samad *et al.,* 2010). Abdelaziz *et al.* (2021) concluded that spraying high-quality grapevines with amino acids (glutamic acid, glycine, and aspartic acid) at a concentration of 250 mg L^{-1} over two study seasons significantly increased the number and weight of grapes, total yield, percentage of soluble solids, and total reducing sugar content compared to the control treatment. Zagzog and Qaoud (2023) showed that spraying Arra 15 and Arra 20 grapevines at concentrations of 0.25 and 0.50 g L^{-1}, respectively, significantly increased leaf area, average branch length, number of leaves, and pruning weight over both study periods compared to the control treatment. This study aimed to investigate the effects of spraying sugar alcohols and amino acids on the vegetative growth and quantitative and qualitative characteristics of Halwani grapevines and to determine the optimal concentrations for the study.

Materials and Methods

Location of the Experiment

The study was conducted at the Research Station of the Department of Horticulture and Landscape, College of Agriculture, Tikrit University, during the 2023 growing season, on 9-year-old grape vines of the Halwani cultivar planted at 2×4 m spacing and raised using the pergola method, the vines were pruned in 15-February, leaving 7 fruiting canes with a length of 12 eyes and 7 renewal spurs for each vine. To study the effect of spraying with sugar alcohol (mannitol) containing (organic sugar alcohols 35%, calcium water soluble 2.10% and pH 6-7) at three concentrations 0, 5 and 10 ml L^{-1} and amino acid (Amines-I) containing (free amino acids 28%, nitrogen 8%, organic nitrogen 2.5%, urea 5.5%, organic materials 24% and pH 5±5) at three concentrations 0, 5 and 10 ml L^{-1}, vines were sprayed three times during the growing season: first spray at the beginning of the growing season, second before the flowers open and the third after the berries set. Tween-20 was used as a spreading agent when spraying at a concentration of 0.1 ml L^{-1} to reduce the surface tension of water when spraying on the leaves. The first treatment was sprayed in the morning and after three days the second treatment was sprayed. Table 1 shows some physical and chemical properties of field soil.

Table 1. Some physical and chemical properties of field soil

Properties	Sand (%)	Silt (%	Clay (%)	Texture	N (mg L^{-1})	P (mg L^{-1})	K (mg L^{-1})	Organic matter (%)	pH	EC (des m^{-1})
Result	23.5	47.84	28.66	Silty loom	47	7.8	114	1.37	7.33	3.27

The following properties were studied at the end of the experiment on 2023/8/20:

1. Leaf area of vine (m^2): It was measured according to the method of (Al-Rawi, 2005) following equation:

$$\text{Leaf area of vine} = \frac{leaf\ area}{number\ of\ leaves}$$

2. Leaf content of chlorophyll (mg g^{-1} fresh weight): It was estimated according to the method of (Knudson *et al*., 1977). The leaves were cut into small pieces and weighed 0.25 g of the cut leaves and 15 mL of 95% concentrated ethanol was added to them and stored in a dark place for 24 hours. The process was repeated three times and the solution was measured by a spectrophotometer type (100 v-1 lab EMC) at a wavelength of 665 and 649 nanometers and according to both chlorophyll a and b the following equations:

$$\text{Chlorophyll a} = (13.70)(A665) - (5.76)(\text{A649})$$
$$\text{Chlorophyll b} = (25.80)(A649) - (7.60)(\text{A665})$$
$$\text{Total chlorophyll} = chlorophyll\ a + chlorophyll\ b$$

3. Average number of clusters (cluster $vine^{-1}$): The number of clusters per vine was counted in all experimental units in each replicate and then their average was calculated.

4. Average cluster weight (g): Calculated according to the method of Al-Doori and Hussein (2024) following equation:

$$\text{Average clusters weight} = Total\ yield\ weight\ per\ vine \div \text{number of cluster per vine}$$

5. Total vine yield (kg $vine^{-1}$): Calculated according to the method of Al-Doori and Hussein (2024), following equation:

$$\text{Total vine yield} = \text{Average cluster weight per vine} \times \text{Number of cluster per vine}$$

6. Yield per hectare (kg $hectare^{-1}$): The yield of one experimental unit was calculated, and then the yield of one hectare was calculated using the ratio and proportion method.

7. Total soluble solids (%): This percentage was calculated using a hand refractometer.

8. Total sugar (%): It was estimated by taking 1 ml of juice from 10 berries for each experimental unit, then adding 1 ml of phenol at a concentration of 5% and about 18 ml of distilled water, shaking well, then adding 5 ml of concentrated sulfuric acid 97% and placing it in a water both for 30 minutes at a temperature of 60 ºC. After that, 10 ml of it was taken and placed in a centrifuge for 15 minutes at a speed of 3000 rpm^{-1}. The filtrate was then separated and the total sugars were read in a spectrophotometer at a wavelength of 490 nm after clearing the device with distilled water (Joslyn, 1970) according to the following equation:

$$\text{Total sugars \%} = \text{Device reading} \times \text{dilution} \times \text{constant factor } (0.0525) \times 100$$

9. Total acidity (%): Ten berries were cut for each experimental unit, then placed in a blender for 2-3 minutes after which the juice was filtered and the percentage acidity was calculated by titrating the filtered juice with 0.1% sodium hydroxide base until the equivalence point was reached using 2-3 drops of naphthalene indicator and then estimated according to the method of (Ranganna, 1977), based on tartaric acid as the prevalent acid in grapes.

10. Fruits content of anthocyanin (mg $100g^{-1}$ fresh weight): Estimated according to the method of (Ranganna, 2011) by extracting anthocyanins from fresh berries using alcoholic hydrochloric acid (HCl) consisting of 95% ethyl alcohol and HCl (1.5) in a ratio of 85:15, by taking 1 g of mixed fresh fruits and mixing it in 20 ml of acidified alcohol and leaving it for 24 hours at 40 ºC, then filtering it using filter paper and then estimating it using a spectrophotometer type EMC lab v-1 100 at a wavelength of 535 nm.

Statistical Analysis

The experiment used a split-plot design according to a complete randomized block with three replicates per experimental unit and two grapevines per group. Therefore, the number of grapevines included in the experiment was 54. Data were statistically analyzed according to the anova table using the (SAS, 2001) system for analyzing agricultural experiments. The averages were compared using Duncan's multiple range test at a probability level of 0.05 (Mead *et al.,* 2003).

Result and Discussions

1. Leaf area of vine (m^2)

The results shown in Table 2 show that spraying the Halwani grape vines with sugar alcohol (mannitol) at two concentrations of 5 and 10 ml L^{-1} led to a significant increase in the leaf area of the grape vines, which reached 6.90, 7.19 m^2, respectively, compared to the control treatment, which recorded the lowest rate, which reached 5.95 m^2. Spraying with two concentrations of 5 and 10 ml L^{-1} of amino acid (Amines-I) led to a significant increase in the same trait, reaching 6.85 and 6.96 m^2, respectively, with an increase rate over the comparison treatment of 9.95 %.
The interaction between the two factors, sugar alcohol and amino acid, led to a significant improvement in the leaf area of the grapevine. Spraying with a concentration of 10 ml L^{-1} of sugar alcohol combined with spraying with a concentration of 5 ml L^{-1} of amino acid recorded the highest rate, reaching 7.40 m^2, which did not differ significantly from the interaction treatment with a concentration of 10 ml L^{-1} of sugar alcohol combined with spraying with a concentration of 10 ml L^{-1} of amino acid, which reached 7.29 m^2, and both of them outperformed the control treatment, which recorded the lowest rate, reaching 5.10 m^2.

Table 2. Effect of spraying sugar alcohols and amino acid on leaf area of vine (m^2)

Sugar Alcohol (ml L^{-1})	Amino Acid (ml L^{-1})			Average Sugar Alcohol
	0	5	10	
0	5.10 e	6.25 d	6.50 cd	5.95 b
5	6.70 bcd	6.90 abc	7.10 ab	6.90 a
10	6.89 abc	7.40 a	7.29 a	7.19 a
Average Amino Acid	6.23 b	6.85 a	6.96 a	

Values with similar letters are not significantly different according to Duncan multiple testing with 0.05 probability.

2. Leaf content of chlorophyll (mg g^{-1} fresh weight)

The results of Table 3 showed that spraying the Halwani grape vines with sugar alcohol (mannitol) at two concentrations of 5 and 10 ml L^{-1} led to a clear significant improvement in the chlorophyll content of the leaves, which reached 28.23, 28.32 mg g^{-1} fresh weight, respectively, compared to the control treatment, which recorded the lowest rate, reaching 27.46 mg g^{-1} fresh weight, while the chlorophyll content of the leaves increased when spraying with a concentration of 10 ml L^{-1} of the amino acid, significantly, and reached 28.56 mg g^{-1} fresh weight, an increase of 4.24% over the control treatment. The two-factor interaction had a significant effect in improving the chlorophyll content of the leaves, as the spraying treatment with a concentration of 10 ml L^{-1} of sugar alcohol combined with spraying with a concentration of 10 ml L^{-1} of amino acid recorded a significant increase of 29.06 mg g^{-1} fresh weight compared to the control treatment, which recorded the lowest content, reaching 26.83 mg g^{-1} fresh weight.

Table 3. Effect of spraying sugar alcohol and amino acids on leaf content of chlorophyll (mg $gram^{-1}$)

Sugar Alcohol (ml L^{-1})	Amino Acid (ml L^{-1})			Average Sugar Alcohol
	0	5	10	
0	26.83 e	27.38 de	28.17 abcd	27.46 b
5	27.87 bcd	28.34 abc	28.47 ab	28.23 a
10	27.47 cde	28.43 ab	29.06 a	28.32 a
Average Amino Acid	27.39 c	28.05 b	28.56 a	

Values with similar letters are not significantly different according to Duncan multiple testing with 0.05 probability.

3. Average number of clusters (cluster $vine^{-1}$)

The results shown in Table 4 show that the number of clusters in the vine was significantly affected by spraying with sugar alcohols and amino acids, as spraying with concentrations of 5 and 10 ml L^{-1} of sugar alcohol (mannitol) led to a significant increase of 31.50 and 31.22 cluster $vine^{-1}$ respectively for both concentrations compared to the control treatment which amounted to 29.78 cluster $vine^{-1}$. The effect of spraying with concentrations of 5 and 10 ml L^{-1} of amino acid was to significantly increase the same trait, reaching 31.72 and 30.89 cluster $vine^{-1}$ compared to the control treatment, which reached 29.89 cluster $vine^{-1}$. The effect of the two-factor interaction between sugar alcohol and amino acid was significant in increasing the number of grapevine clusters, as the spraying treatment with a concentration of 5 ml L^{-1} of sugar alcohol combined with spraying with a concentration of 10 ml L^{-1} of amino acid recorded the highest rate, reaching

32.67 cluster vine^{-1} compared to the control treatment, which recorded the lowest rate, reaching 29.00 cluster vine^{-1}.

Table 4. Effect of spraying sugar alcohols and amino acid on the average number of clusters (cluster vine^{-1})

Sugar Alcohol (ml L^{-1})	Amino Acid (ml L^{-1})			Average Sugar Alcohol
	0	5	10	
0	29.00 d	29.50 cd	30.83 bc	29.78 b
5	30.00 bcd	31.83 ab	32.67 a	31.50 a
10	30.67 bcd	31.33 ab	31.67 ab	31.22 a
Average Amino Acid	29.89 b	30.89 a	31.72 a	

Values with similar letters are not significantly different according to Duncan multiple testing with 0.05 probability.

4. Average cluster weight (g)

The results below in Table 5 showed that the cluster weight trait in the Halwani grape vines was significantly affected by spraying with sugar alcohol (mannitol) at a concentration of 10 ml L^{-1}, as it recorded the highest rate of 529.87 g, with an increase rate over the control treatment of 14.08%, while spraying with two concentrations of 5 and 10 ml L^{-1} of the amino acid (Amines-I) led to a significant superiority in the same trait, as it reached 516.34, 529.98 g respectively, compared to the control treatment, which reached 452.39 g. While the dual interaction led to a significant increase in the weight of the clusters, spraying with a concentration of 10 ml L^{-1} of sugar alcohol combined with spraying with a concentration of 10 ml L^{-1} of amino acid recorded the highest rate in the weight of the cluster, reaching 547.95 g, compared to the control treatment, which recorded the lowest rate, reaching 391.66 g.

Table 5. Effect of spraying sugar alcohols and amino acid on average cluster weight (g)

Sugar Alcohol (ml L^{-1})	Amino Acid (ml L^{-1})			Average Sugar Alcohol
	0	5	10	
0	391.66 f	491.67 de	510.00 bcd	464.44 c
5	466.16 e	515.01 abcd	532.00 abc	504.39 b
10	499.33 cd	542.33 ab	547.95 a	529.87 a
Average Amino Acid	452.39 b	516.34 a	529.98 a	

Values with similar letters are not significantly different according to Duncan multiple testing with 0.05 probability.

5. Total vine yield (kg vine^{-1})

The results of the statistical analysis in Table 6 showed that spraying with a concentration of 10 mL L^{-1} of sugar alcohol led to a significant increase in the yield of the Halwani grape vine, which amounted to 16.55 kg, with an increase rate over the control treatment of 19.49%. Spraying with a concentration of 10 ml L^{-1} of amino acid led to a significant increase in the yield of the vine, which amounted to 16.81 kg, with an increase rate over the control treatment of 7.38%. While the interaction between the two factors had a clear moral effect in improving the same trait, the spraying treatment with a concentration of 10 ml L^{-1} of sugar alcohol interacted with the spraying with a concentration of 10 ml L^{-1} of amino acid and the interaction treatment of 5 ml L^{-1} of sugar alcohol interacted with a concentration of 10 ml L^{-1} of amino acid recorded the highest rate, reaching 17.37 kg, which did not differ significantly with the interaction treatment of 10 ml L^{-1} of sugar alcohol interacted with a concentration of 5 ml L^{-1} of amino acid, which reached 16.99 kg compared to the control treatment, which recorded the lowest rate of 11.36 kg.

Table 6. Effect of spraying sugar alcohols and amino acid on total vine yield (kg $vine^{-1}$)

Sugar Alcohol (ml L^{-1})	Amino Acid (ml L^{-1})			Average Sugar Alcohol
	0	5	10	
0	11.36 f	14.50 de	15.71 bc	13.85 c
5	13.97 e	16.40 ab	17.37 a	15.91 b
10	15.31 cd	16.99 a	17.35 a	16.55 a
Average Amino Acid	13.55 c	15.96 b	16.81 a	

Values with similar letters are not significantly different according to Duncan multiple testing with 0.05 probability.

6. Yield per hectare (kg $hectare^{-1}$)

The results of Table 7 show that the yield per hectare was significantly affected by spraying with concentrations of 5 and 10 ml L^{-1} of sugar alcohol (mannitol) and amounted to (19.81, 20.45) kg ha^{-1}, significantly superior to the control treatment, which amounted to 17.32 kg ha^{-1}. The effect of spraying with a concentration of 10 ml L^{-1} of amino acid (Amines-I) was to significantly increase the same trait and recorded the highest rate of 20.93 kg ha^{-1} compared to the control treatment, which recorded the lowest rate of 16.70 kg ha^{-1}. The two-factor interaction of 10 ml L^{-1} of sugar alcohol combined with 10 ml L^{-1} of amino acid recorded the highest rate of grapevine yield per hectare, reaching 21.68 kg ha^{-1}, which did not differ significantly with spraying with 10 ml L^{-1} of sugar alcohol combined with spraying with 5 ml L^{-1} of amino acid and spraying with 5 ml L^{-1} of sugar alcohol combined with spraying with 10 ml L^{-1} of amino acid, which reached (21.24 and 21.47) kg ha^{-1}, respectively, for both interaction treatments, significantly superior to the control treatment, which recorded the lowest rate of 14.20 kg ha^{-1}.

Table 7. Effect of spraying sugar alcohols and amino acid on yield per hectare (kg $hectare^{-1}$)

Sugar Alcohol (ml L^{-1})	Amino Acid (ml L^{-1})			Average Sugar Alcohol
	0	5	10	
0	14.20 e	18.12 d	19.63 bc	17.32 b
5	17.46 d	20.49 ab	21.47 a	19.81 a
10	18.41 cd	21.24 a	21.68 a	20.45 a
Average Amino Acid	16.70 c	19.95 b	20.93 a	

Values with similar letters are not significantly different according to Duncan multiple testing with 0.05 probability.

7. Total soluble solids (%)

The results of Table 8 show that spraying with concentrations of 5 and 10 ml L^{-1} of sugar alcohols (mannitol) led to a significant increase in the percentage of total soluble solids, which reached 15.31, 15.62 %, respectively, compared to the control treatment, which reached 14.91%. Spraying with concentrations of 5 and 10 ml L^{-1} led to a significant increase in this characteristic, which reached 15.33, 15.62 %, respectively, compared to the control treatment, which reached 14.89%.The effect of the two-factor interaction between the concentrations of the two factors had a significant effect on this trait, as spraying with a concentration of 10 ml L^{-1} of sugar alcohol combined with spraying with a concentration of 10 ml L^{-1} of amino acid recorded the highest percentage of dissolved solids, reaching 16.47%, compared to the control treatment, which recorded the lowest rate, reaching 14.28%.

Table 8. Effect of spraying sugar alcohols and amino acids on TSS (%)

Sugar Alcohol (ml L^{-1})	Amino Acid (ml L^{-1})			Average Sugar Alcohol
	0	5	10	
0	14.28 c	15.21 b	15.23 b	14.91 b
5	15.18 b	15.30 b	15.45 b	15.31 a
10	15.22 b	15.47 b	16.47 a	15.62 a
Average Amino Acid	14.89 b	15.33 a	15.62 a	

Values with similar letters are not significantly different according to Duncan multiple testing with 0.05 probability.

8. Total sugar (%)

The results of Table 9 showed that spraying the vines of the Halwani variety with a concentration of 10 ml L^{-1} of sugar alcohol recorded the highest rate of total sugars in the grapes, reaching 13.630%, which did not differ significantly from spraying with a concentration of 5 ml L^{-1}, which reached 13.524%, significantly outperforming the control treatment, which recorded the lowest percentage, reaching 13.344%, while spraying with a concentration of 10 ml L^{-1} of amino acid (Amines-I) resulted in the highest percentage of total sugars, reaching 13.643%, which did not differ significantly from the concentration of 5 ml L^{-1}, which reached 13.535%, significantly outperforming the control treatment, which recorded the lowest percentage, reaching 13.320%. The two-way interaction between the two factors resulted in a significant increase in the percentage of total sugars in the grains, as the interaction treatment of spraying with a concentration of 10 ml L^{-1} of sugar alcohol combined with spraying with a concentration of 10 ml L^{-1} of amino acid recorded the highest percentages, reaching 13.830%, which did not differ significantly from the two interaction treatments of 10 ml L^{-1} of sugar alcohol combined with a concentration of 5 ml L^{-1} of amino acid and the treatment of 5 ml L^{-1} of sugar alcohol combined with a concentration of 10 ml L^{-1} of amino acid, which both reached 13.650%, significantly superior to the control treatment, which recorded the lowest percentages, reaching 13.150%.

Table 9. Effect of spraying sugar alcohols and amino acids on total sugar (%)

Sugar Alcohol (ml L^{-1})	Amino Acid (ml L^{-1})			Average Sugar Alcohol
	0	5	10	
0	13.150 b	13.431 ab	13.450 ab	13.344 b
5	13.399 ab	13.524 ab	13.650 a	13.524 ab
10	13.410 ab	13.650 a	13.830 a	13.630 a
Average Amino Acid	13.320 b	13.535 ab	13.643 a	

Values with similar letters are not significantly different according to Duncan multiple testing with 0.05 probability.

9. Total acidity (%)

Spraying Halwani grape vines with sugar alcohol (mannitol) and amino acid (Amines-I) significantly reduced the total acidity of the berries, as shown in Table 10. The spraying treatment with a concentration of 5 ml L^{-1} of sugar alcohol recorded the lowest percentages, followed by the spraying treatment with a concentration of 10 ml L^{-1}, which reached (0.318 and 0.308) %, respectively, compared to the control treatment, which recorded the highest percentage of 0.323%. The spraying with a concentration of 10 ml L^{-1} of amino acid recorded the lowest percentage of acidity of the berries, reaching 0.304%, compared to the control treatment, which recorded the highest percentage of 0.325%. While the two-factor interaction had a significant effect in reducing the acidity rate, the interaction treatment with a concentration of 10 ml L^{-1} of sugar alcohol interacting with a concentration of 10 ml L^{-1} of amino acid recorded the lowest rate of 0.296%, while the control treatment recorded the highest rate of 0.330%.

Table 10. Effect of spraying sugar alcohols and amino acids on total acidity (%)

Sugar Alcohol (ml L^{-1})	Amino Acid (ml L^{-1})			Average Sugar Alcohol
	0	5	10	
0	0.330 a	0.327 ab	0.312 abc	0.323 a
5	0.328 a	0.320 ab	0.305 bc	0.318 ab
10	0.315 abc	0.311 abc	0.296 c	0.308 b
Average Amino Acid	0.325 a	0.320 a	0.304 b	

Values with similar letters are not significantly different according to Duncan multiple testing with 0.05 probability.

10. Fruits content of anthocyanin (mg $100g^{-1}$ fresh weight)

The results of Table 11 show that spraying with concentrations of 5 and 10 ml L^{-1} of sugar alcohol led to a significant increase in the fruit content of anthocyanin, which reached (0.798 and 0.814) mg $100g^{-1}$ fresh weight, respectively, compared to the control treatment, which reached 0.758 mg $100g^{-1}$ fresh weight, while spraying with concentrations of 5 and 10 ml L^{-1} of amino acid led to a significant increase in the same trait, which reached (0.799 and 0.811) mg $100g^{-1}$ fresh weight, compared to the control treatment, which reached 0.760 mg $100g^{-1}$ fresh weight. The two-way interaction between the concentrations of the factors had a significant effect in improving the anthocyanin content of the berries, as the interaction treatment with a concentration of 10 ml L^{-1} of sugar alcohol interacted with a concentration of 10 ml L^{-1} of amino acid recorded the highest rate of 0.837 mg $100g^{-1}$ fresh weight, significantly outperforming the rest of the interactions, while the control treatment recorded the lowest rate of 0.740 mg $100g^{-1}$ fresh weight.

Table 11. Effect of spraying sugar alcohols and amino-acid on fruits content of anthocyanin (mg $100g^{-1}$ fresh weight)

Sugar Alcohol (ml L^{-1})	Amino Acid (ml L^{-1})			Average Sugar Alcohol
	0	5	10	
0	0.740 d	0.763 cd	0.771 cd	0.758 b
5	0.760 cd	0.810 abc	0.825 ab	0.798 a
10	0.780 cd	0.826 ab	0.837 a	0.814 a
Average Amino Acid	0.760 b	0.799 a	0.811 a	

Values with similar letters are not significantly different according to Duncan multiple testing with 0.05 probability.

Reasons for the improvement in plant growth characteristics when spraying with sugar alcohols may be due to: Mannitol is one of the forms of alcoholic sugar that facilitate the transfer of the boron element present within the phloem in the form of a complex of mannitol, natural boron and many smaller elements present within the phloem (Brown and Hu, 1996). In addition to the effect of mannitol on the permeability of cell membranes due to the small size leaves during the spraying process through the stomata and accumulates in the plant tissues, sugar alcohols are also considered carbohydrates, which leads to an increase in the primary metabolic products of carbohydrates, such as proteins, peptides, pectin substances and organic acids, which affect the vital processes of the plant, such as respiration, energy release and ATP production, which participate in plant growth by increasing cell division (Taiz and Zeiger, 2010) which is reflected in increased cell elongation and improved vegetative growth characteristics (Tables 2 and 3). Sugar alcohols also act as hydrogen receptors, increasing the activity of enzymes that play an important role in interacting with phospholipid compounds found in cell membranes, which transport nutrients from outside the cell to inside it, thus increasing the absorption of water and nutrients (Taiz and Zeiger, 2010).which in turn is reflected in the improvement of the quantitative characteristics of the, Tables (4, 5, 6 and 7), the source of sugars in grapes is the process of photosynthesis in the leaves, which are the main sites for the production of total or reduced sugars and their transfer to storage organs such as clusters and growing tips (Al-Saeedi, 2000; Hussein and Al-Doori, 2025) which causes an increase in its content in the fruits and is reflected in the anthocyanin pigment, of which sugars represent 70% of the pigment (Tables 8,9 and 11) due to the abundance of sugars as a result of the availability of nutrients manufactured by the shoots, this was reflected in decrease in the acidity percentage in the fruits, as a result of its role in accelerating the berries' ripening Table (10) these results are in agreement with Khazraji and Al-Douri (2025) In their study of the effect of sugar alcohols on grape vines and Hussein and Zaili (2025).

As for the improvement in the vegetative growth of grapevines when sprayed with amino acid, it may be due to the role of amino acid in the metabolic activities of the plant, as it enters into the construction of nucleic acids DNA and RNA, which are necessary for cell growth and formation and it also enters into the composition of a number of enzymes that participate in the process of photosynthesis and supplying the plant with nitrogen, it also participates in the synthesis of other organic compounds, as well as proteins, vitamins, alkaloids, amines and others (Wallsgrove, 1995; Verma, 2007) Amino acids also encourage vital activities, especially the processes of division and expansion of plant cells and increase the activity of enzymes that work to decompose organic compounds and release elements, which increases their availability and in turn increases plant growth (Abdel-Hafez, 2006) which is reflected in the increase in leaf are, Table (2). Amino acids increase chlorophyll in the leaves, Table (3) due to their role in reducing the absorption of sodium ions, in addition to their role in delaying leaf aging, as they are a source of nitrogen (Farman *et al.,* 2019) as a result of the increase in vegetative growth indicators such as leaf area and leaf chlorophyll content, which leads to improving the nutritional status of the plant and thus increasing the amount of manufactured carbohydrates, which encourages flower growth and improves fruit set. Due to the suitable environmental conditions that help transfer the manufactured materials from the leaves to the fruits, which causes an increase in the number and weight of the fruits, which is positively reflected in increasing the plant's yield, both quantitatively and qualitatively, and this agrees with Abdelaziz *et al*., (2021); Al-Doori and Hussein (2023).

Conclusions

We conclude from the study that the factors used (sugar alcohol and amino acid) sprayed on the vegetative group played an effective role in improving the vegetative characteristics and the quantitative and qualitative yield characteristics of the Halwani grape vines under the conditions of the current study. Spraying with sugar alcohol (mannitol) had a positive effect in improving the studied characteristics, and the best results were obtained when spraying at concentrations of 5 and 10 mL L^{-1}. The amino acid (Amines-I) had a clear effect in improving the vegetative growth, yield and fruit quality traits, and the values of most of the mentioned traits increased significantly with increasing the concentration of the amino acid. The combined factors led to an improvement in most traits when paired, indicating the combined role of these factors.

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Conflict of Interests

The authors declare no conflicts of interest associated with this manuscript.

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Author Contribution

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