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Influence of Anti-Transpirant, Nano-Potassium, and Shading on Vegetative Growth, Grape Qualities, Yield and phytochemicals of Grapevines (Tre-Rash cv.) Under Rain-Fed Conditions

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Abstract

Agricultural production is considered one of the sectors most affected by climate change, especially drought; in the semi-arid climate zone, rainfall is variable leading to several challenges that affect agricultural production. Thus, this study was conducted using antitranspirant (1:10), nano-potassium (2 g L^{-1}) and 50% shading with a green net to protect grapevines, *Vitis vinifera* L., cv. Tre-Rash under rain-fed conditions. A simple randomized complete block design experiment was conducted to enhance grape yield and quality, to explore the synergistic effects of the treatments used on grapevines grown under water-limited conditions. The results showed that the treatments significantly enhanced some vegetative traits such as main shoot length and chlorophyl content. Moreover, the variance among values of cluster weight, number of berries per cluster, weight of 100 berries, size of 100 berries, total soluble solid TSS, total titratable acid TA, total anthocyanin content in grape, total carotenoid, total soluble sugar content in grapes and leaves, total phenolic content in grapes and leaves, total flavonoid content in grape and leaves, leaf proline, leaf lipid peroxidation and yield per vine were significantly different.

Keywords: Vitis vinifera L., Drought stress, phytochemical, grape quality.

I. Introduction:

Grapes (*Vitis vinifera* L.), classified as members of the Vitaceae family, have been cultivated since ancient times in the Mesopotamian Valley and are recognized as one of the most important horticultural crops across the worldwide, including in Iraq. Nowadays, more than 100 cultivars are grown, with the majority located in the Kurdistan Region (Abiri *et al.*, 2020; Hussein *et al.*, 2022 and Al-jubori, 2023). Grapevines are well-suited to arid and semi-arid climates due to their deep root systems, efficient stomatal control, and osmotic adjustment, which make them resilient under water-limited conditions (Chacón-Vozmediano *et al.*, 2020 and Romero *et al.*, 2025). The region has experienced increasingly semi-arid conditions due to climate change, characterized by rising temperatures, reduced rainfall, and declining surface water and vegetation. These environmental changes pose serious threats to agricultural productivity (Al-Quraishi & Negm, 2020).

Drought stress leads to dehydration of plant cells, reduced nutrient uptake, and limited carbon dioxide assimilation due to stomatal closure, ultimately contributing to decreased crop productivity (Begna, 2020 and Zahedi *et al.*, 2025). In such conditions, antitranspirants can mitigate drought effects by reducing water loss through transpiration, especially in

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semi-arid regions where water absorption is consistently lower than transpiration. antitranspirants are compounds applied to foliage to minimize water loss by either forming a protective film on leaf surfaces or modifying stomatal behavior, thereby helping to maintain plant hydration (Moghith, 2024).

Potassium an essential mineral recognized as a fruit qualities component, it has positive result on improving fruit quality and quantity. enhancement of fruit traits related with potassium may be attributed to several factors, include raised accumulation of assimilates, expansion of the cells and enlargement of fruit tissue volume, all of prior factors contribute to enhancer fruit weight. Additionally, in a rainfed system, with water and nutrients are limited, nano-potassium proves especially advantageous. It enhances nutrient use efficiency, strengthens root growth, and improves plant tolerance to environmental stress (Alharbi *et al*., 2024).

However, grape berry size can be influenced by sunlight exposure (Torres *et al*., 2020). Moreover, in late summer, grape berries are subjected to exposure to excessive solar radiation, resulting in increased sunburn damages and alterations in the berries' visual and organoleptic qualities (Palliotti *et al*., 2014 and Gambetta *et al*., 2021). To mitigate the effects of solar radiation, shading by a net plays an active role in limiting the effects of high temperatures and reducing direct sunlight exposure (Miccichè *et al*., 2025)

Tre-Rash grape cultivar considered one of the locally grapevine cultivars which cultivated in Kurdistan under rain-fed conditions. Reducing rainfall and increasing temperatures caused to conduction this study aims to boost some vegetative growth traits, enhance some characteristics of berries and vine yield (Mahmood *et al.,* 2022).

II. Materials and Methods:

This field trial was carried out during the 2025 growing season on the 12-years-old grapevine cultivar Tre rash, in a private vineyard under rainfed condition located in Dukanian, Shar-bazher, Sulaymaniyah Governorate, Kurdistan Regional, Iraq. The location coordinate is 35°34'37.8"N 45°30'58.8"E with 890 m above sea level (Figure 1).

At the end of the experiment, soil samples at 0-30 cm depth collected randomly from several place within the vineyard, thoroughly mixed, the soil was then analyzed at the central laboratory, Department of Biology, College of Science, University of Baghdad, and the results of the soil analyses are presented in (Table 1). The meteorological data were shown in (Table 2)

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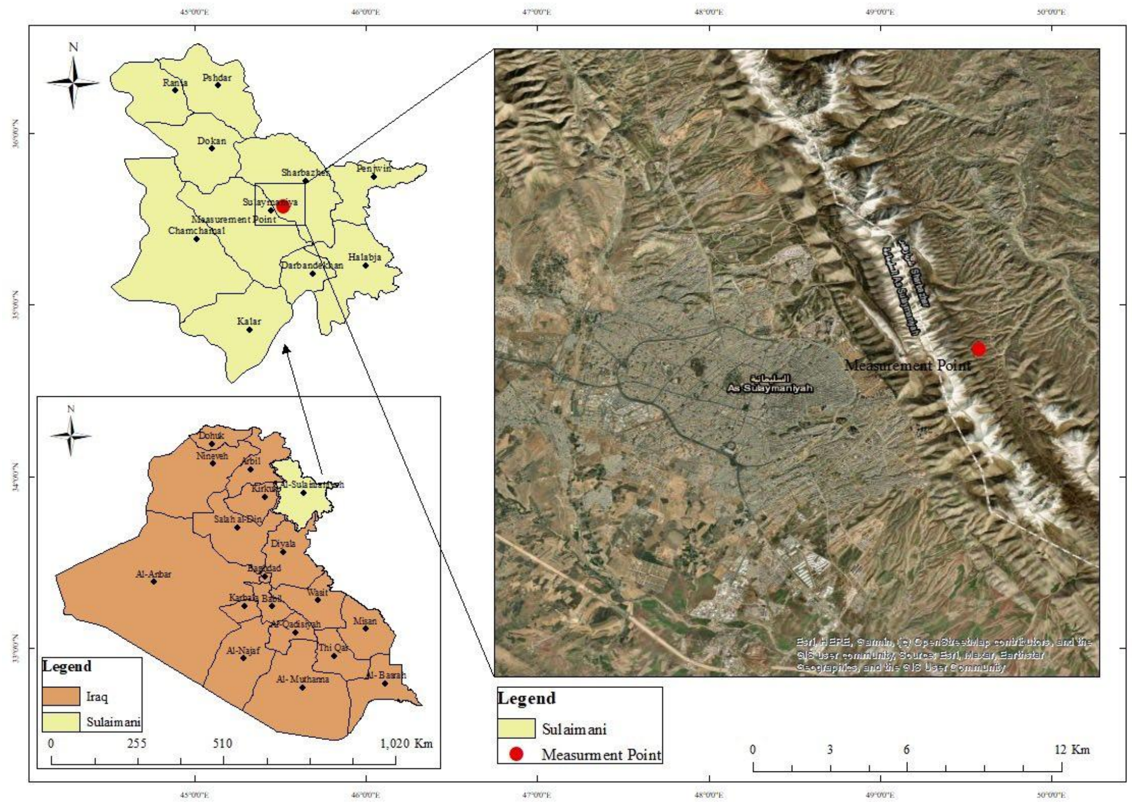

Figure 1 Map of experiment study site

Table 1: Some soil chemical and physical properties in the experimental location.

Soil Components	Value	Unit	Soil Texture Class
Silt	453.6		
Sand	296.4		
Clay	250.0	g kg^{-1}	Loam
Organic Matter	15.5		
Available Nitrogen	52	mg kg^{-1}	
Available Phosphate	16		

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Available Potassium	46		pH
EC	1.16	dS m^{-1}	7.55

Table 2: Some meteorological data of the study location during 2024-2025.

Months	Temperature °C			Rainfall (mm)
	Aver.	Max.	Min.	
9/2024	25.8	40.2	11.3	0.5
10/2024	18.6	32.1	5.0	0.0
11/2024	14.1	24.2	4.0	197
12/2024	5.6	15.2	-4.0	95.5
1/2025	5.0	15.3	-5.3	46.5
2/2025	3.0	14.0	-8.1	132
3/2025	12.8	23.4	2.1	58
4/2025	18.6	29.1	8.0	76
5/2025	26.2	37.2	15.2	32.5
6/2025	29.5	40.2	18.8	0
7/2025	35.55	44.8	26.3	0
8/2025	34.15	44.1	24.2	0

Vine Selection:

In a private vineyard 24 uniform vines (Tre-Rash cultivar) were selected as uniform in vigor, size, healthy, and good physical condition. The vine pruning was performed during the dormant stage on March 11, 2025 by leaving five fruiting spurs on each vine, with four buds per spur, resulting in a total of 20 buds per vine. Vines are spacing at 2.5 x 3 meters apart and the rows were arranged from Northwest to Southeast and trained according to the head training system. All vines undertaken in this study received the standard agricultural practices often used in commercial vineyards. The harvest date had been noted after the TSS of berries reached 16% (Al-Saidi, 2000) and the color changed to black.

Treatment application

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Wilt pruf Products, Inc., Essex, CT, USA antitranspirant manufactured in United States of America was applied by spraying the solution onto the vine's vegetative growth. The concentrated antitranspirant was diluted with distilled water at concentration at a ratio 1:10 L according to producer recommended dose. The antitranspirant was applied in two time: the first application was before veraison (18 June 2025), and the second was two weeks after the veraison stage (15 July 2025). On another hand, the veraison stages (pre and post) compose the most sensitive phenological phases in grapevines, during which water stress has the greatest effect on grape yield and berry quality (Albrizio *et al.*, 2023). Foliar applications of Nano potassium fertilizer at concentration (2 g. L^{-1}) according to the manufacturer's recommendations, were used by applying the solution to the vine's vegetative growth using the foliar application method spraying at key growth stages three times (beginning of vegetative growth, after fruit set stage, at version stage). Shading is one of the treatments of this study in which we applied green color net with 50% shading, that were applied three weeks after fruit setting stage of the growing season at (12 June 2025).

Experimental Design and Statistical Analysis:

The experiment was conducted using a simple randomized complete block design (RCBD) with 8 treatments, each replicated three times and randomly assigned within each block. A total of 24 vines were used. Treatment combinations were applied accordingly to evaluate their interactive effects, as follows:

- T1 = Control
- T2 = Antitranspirant
- T3 = Nano potassium fertilizer
- T4 = Shading
- T5 = Antitranspirant + Nano potassium fertilizer
- T6 = Antitranspirant + Shading
- T7 = Nano potassium fertilizer + Shading
- T8 = Antitranspirant + Nano potassium fertilizer + Shading

The measured vegetative traits were main shoot length (cm), main shoot diameter (mm), single leaf area (cm^2) and leaf chlorophyll concentration (SPAD), about the physical grape traits cluster weight (g), weight of 100 berries (g), size of 100 berries (cm^3), Juice (%) and berry firmness (N). The measured chemical traits were total soluble solids (TSS%), total titratable acid (TTA%), grape total anthocyanin content (mg 100 g^{-1} FW) according to (Ranganna, 2011), total soluble sugar content of grape and leaves (µg g^{-1} FW) according to (Rasul, 2023), total phenolic content in grape and leaves (µg GAE g^{-1} FW) according to (Rasul, 2023), total flavonoids content in grape and leaves (µg QE g^{-1} FW) according to (Rigane *et al.*, 2017), leaf content of proline (µg g^{-1} FW) according to (Rasul, 2023) and leaf content of lipid peroxidation (nmol g^{-1}) according to (Rasul, 2023).

The data were analyzed using XLSTAT software. Analysis of variance (ANOVA) was performed to test the significance of the treatment effects. Means were compared using Duncan's Multiple Range Test at the 5% level of significance (Al-Rawi & Khalafalla, 2000).

III. Results and Discussions:

Vegetative traits:

The arranged data in Table 3 show the effect of antitranspirant, nano-potassium, shading and their combinations on some vegetative parameters on vine, about main shoot length the maximum significant value (199.63 cm) was obtained in the T8, which presents the interaction among the three treatments of the experiment, the second and third highest values

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recorded by T3 and T7 which were (186.67 and 184.70 cm) respectively, the lowest value was recorded by the control (T1) which was (148.03 cm). The increase of shoot length by antitranspirant application may be due to that explained by (Fahmy, 2023) which was mentioned, antitranspirant application (film formation type) has positive effect on vegetative growth by protecting plant leaves from damage and reducing transpiration. Nano-potassium application led to an increase in shoot length because potassium acts as a key role in regulating the cell osmotic potential and the stomatal opening and closing is controlled by potassium. It also has significant role in rising photosynthesis when it is obtainable in proper quantities (Taiz & Zeiger, 2010). Furthermore, Köse (2014) explain that with reducing light intensity increasing of shoot length occurred, moreover shading grapevines by green net led to increase shoot length may be due to the shade treatment led to lessen in temperature about 2°C. Therefore, biochemical and physiological processes in leaf and berry worked actively compared to those exposed to direct sunlight (Caravia *et al.*, 2016 and Qiu *et al.*, 2016).

About, values of single leaf area shown in (Table 3), no significant differences recorded among them, the maximum and minimum values were (95.90 and 82.88 cm^2) obtained in (T5 and T1) respectively.

The treatments significantly affected on leaves chlorophyl concentrations (Table 3), maximum significant value (20.63 SPAD) recorded by shade treatment (T4), minimum value (13.42 SPAD) recorded by non-treated grapevine. These differences in recorded values may be attributed to that demonstrated by (Abdallah *et al.*, 2019) that drought stress disrupts the photosynthetic pigments caused damage to the photosynthetic prosses, reducing gas exchange, causing a decrease the plant growth and productivity. Chlorophyll content inhibition in most plants survive in stress condition may be returned to the disorganization membranes which known as thylakoid, with degradation chlorophyll more than synthesis through the formation of proteolytic enzymes such as chlorophyllase that is in charge of chlorophyll degrading and damaging the photosynthetic apparatus. Also, grape vine considers as one of the plants which close the stomata to facing the drought stress, this stomatal closure effect on the CO_2 diffusion and reduce it, this process led to decreasing photosynthetic activity. The spray of antitranspirant limiting decrease drought stress by retaining more water in the leaves, and led to improve photosynthetic and chlorophyll concentration (Zulkarnaini *et al.*, 2020). About, net shading the lengthy exposure of photosynthetic parts of plants to high degree of light can caused in photoinhibition, this outcome is attributable to an evident of photochemical stress, which may at first lead to reduce photosynthetic performance and in the end lead to the decreasing of pigments (Miccichè *et al.*, 2025). Moreover, Zonouri *et al.* (2014) describe that high temperatures, drought and severe sunlight commonly result in reduce the concentrations of chlorophyll. Also mentioned that plants as a response to drought stress close the stomata, in long term the stomata close caused chloroplast degradation which led to reduce in chlorophyll.

Table 3 Effect of antitranspirant, nano-potassium and shading on some vine vegetative parameters

Treatments	Main Shoot Length (cm)	Single Leaf Area (cm²)	Leaf Chlorophyll Concentration (SPAD)
T1	148.03 d	82.88 a	13.42 c
T2	158.83 cd	84.86 a	15.40 bc
T3	186.67 ab	86.03 a	15.50 bc
T4	175.20 bc	84.70 a	20.63 a
T5	175.17 bc	95.90 a	17.13 abc
T6	170.80 bc	93.32 a	19.27 ab

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T7	184.70 ab	85.80 a	19.17 ab
T8	199.63 a	86.75 a	20.13 ab

T1 = Control, T2 = Antitranspirant, T3 = Nano potassium fertilizer, T4 = Shading, T5 = Antitranspirant + Nano potassium fertilizer, T6 = Antitranspirant + Shading, T7 = Nano potassium fertilizer + Shading and T8 = Antitranspirant + Nano potassium fertilizer + Shading.

Means within each column followed by different letters differ significantly according to Duncan's multiple range test at the 5% level of probability.

Cluster and Berries Physical Traits:

Table 4 shows the effect of antitranspirant, nano-potassium and shading and their combinations on some clusters and berries physical parameters. About the cluster weight maximum value 301.53 g recorded by the grape vine treated with the three factors which used in this experiment (T8), minimum value 171.40 g obtained by control (T1) (Table 4). Treated vine by antitranspirant, potassium and shading (individually or binary or triply) have significant effect on cluster weight compared to the control, the prior results may be due to it is self-evident that lower berries weight and berries number on cluster resulted to lower cluster weight. According to (Pallotti *et al.*, 2025) the antitranspirant spraying maintains the water inside the plant tissue which leads to an increase berries weight and total yield. Bayraktar et al. (2025) illustrate that grape shading might increase potassium accumulation in grape leaves, may be due to decreased transpiration losses.

Significant variance in the weight and size of one hundred berries observed among the treatments as precented in (Table 4), maximum weight of a hundred berries value was 252.85 g recorded by T8 and followed by T3, T5, T7 and T6, these treatments were significantly compared to control which give lowest value (182.67 g). Also, T8 recorded the maximum value of a hundred berries size which was (264.00 cm^3), lowest value was (205.33 cm^3) recorded by T1. According to (Irani *et al.*, 2021) drought stress intensely reduced the weight of grape berries, and vine yield may be due to water reduction which it necessary for growth the cell which be the factor cause reduce berries weight, by using antitranspirants in the hyper-arid zone grape berry weight increased by limiting transpiration, enhancing water use efficiency, and improving photosynthesis (Li *et al.*, 2021), grape microclimate is enhanced by shading and it has significant effects on photosynthesis, shading results in reduced wind and solar radiation which leads to lower transpiration request and more opening of stomates core, these aspects positively regulate berry growth due to utmost of water in the cells, approve of turgor pressure (Guérios *et al.*, 2021), Under drought and hot conditions, the concentration of potassium reduced, in accord with its function in osmotic preservation. Nevertheless, under water stress conditions, the conductance of stomata is interrupted under moderate potassium deficiency. Such behavior propose that plants are limited in their capability to growth under water shortage conditions when it is hardly possible to uptake potassium (Villette *et al.*, 2020). On the berry surface few lenticels and stomata are existing which lead to grape berries transpiration, application of anti transpirant reduce berry transpiration, and remain the cell water holding and swelling and finally the berries size increase (Fahey & Rogiers, 2019). It is common that during grape growth stage a complex stream of physicochemical actions accrue, for example grape chemical composition, change in berry size and its color and flavor. The temperature deems one of the main factors influences both cell enlargement and division, such as described in research conducted by (Dinis *et al.*, 2020) that temperature above 35 °C result to decrease berry growth and size. as shown in Table 2 the maximum temperature was near 45 °C in the study locution. Nonetheless, solar radiation additionally affected on berry growth. These factors can be consideration because both factors (antitranspirant and shading) caused cooling the vine parts.

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Grape juice percentage and berry firmness dose not influenced significantly by the treatments the highest values were (52.92%) and (8.31 N) recorded by (T5) and (T8) respectively.

Table 4 Effect of antitranspirant, nano-potassium and shading on some grape cluster and berries physical parameters.

Treatments	Cluster Weight (g)	Weight of 100 Berries (g)	Size of 100 Berries (cm^3)	Juice (%)	Berry Firmness (N)
T1	171.40 c	182.67 b	205.33 b	48.93 a	6.24 a
T2	290.37 ab	221.33 ab	230.67 ab	52.50 a	6.86 a
T3	280.33 ab	238.51 a	238.67 ab	44.15 a	6.59 a
T4	266.33 ab	219.21 ab	216.00 b	47.24 a	7.31 a
T5	265.17 ab	235.73 a	229.33 ab	52.92 a	7.05 a
T6	237.50 b	230.33 a	238.67 ab	45.26 a	6.57 a
T7	279.93 ab	234.93 a	249.33 ab	52.93 a	7.49 a
T8	301.53 a	252.85 a	264.00 a	48.15 a	8.31 a

T1 = Control, T2 = Anti-transpirant, T3 = Nano potassium fertilizer, T4 = Shading, T5 = Anti-transpirant + Nano potassium fertilizer, T6 = Anti-transpirant + Shading, T7 = Nano potassium fertilizer + Shading and T8 = Anti-transpirant + Nano potassium fertilizer + Shading.
Means within each column followed by different letters differ significantly according to Duncan's multiple range test at the 5% level of probability.

Total yield

Effect of antitranspirant, nano-potassium and shading on grape vine yield illustrated in (Figure 2), the mean values were significantly differences, maximum significant value was (4.76 kg $vine^{-1}$) recorded by (T8), it achieved (17%) of total vineyard yield, followed by (T7) which recorded (4.47 kg $vine^{-1}$) achieved (16%) of total yield. Minimum significant value was (1.43 kg $vine^{-1}$) recorded by untreated vines which was (5%) of the total yield. From the results it is clear that the value of each treatment (T2 -T8) is significantly compared to (T1). These variations on results may be returned to which showed by researchers which are divided in two groups, the first group, showed that in drought stress, the differences of vine yield resulted due to changes the berry weight not cluster number and berries number (Freeman *et al.*, 1979 and Chacón-Vozmediano *et al.*, 2020). In contrast, the second group observed that drought stress was reduced cluster and berry weight and also reduced the cluster number on the grape vine (Girona *et al.*, 2006; Santesteban *et al.*, 2011 and Shellie, 2014), these results are inversely which may obtain due to grape cultivar, location, environmental conditions, irrigation, nutrient, soil type, vine age …. Etc. As described by (Miccichè *et al.*, 2025) the shading led to enhance the weight of clusters and finally increased the total weight of vine. Potassium fertilizer application has a positive influence on various plant activities, which include metabolic, biological and physiological functions. potassium enhances photosynthesis process, and control stomatal closing and opening, which mean it has positive effects on the total yield increasing (Benmoussa & Ben Mimoun, 2025).

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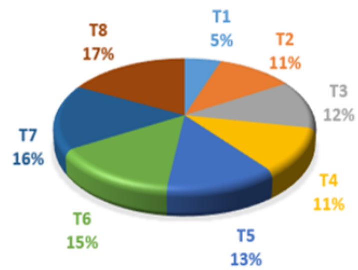

Treatments	Yield per vine (kg)
T1	1.43 d
T2	3.01 c
T3	3.30 bc
T4	3.13 c
T5	3.43 bc
T6	3.99 abc
T7	4.47 ab
T8	4.76 a

T1 = Control, T2 = Anti-transpirant, T3 = Nano potassium fertilizer, T4 = Shading, T5 = Anti-transpirant + Nano potassium fertilizer, T6 = Anti-transpirant + Shading, T7 = Nano potassium fertilizer + Shading and T8 = Anti-transpirant + Nano potassium fertilizer + Shading.
Means within each column followed by different letters differ significantly according to Duncan's multiple range test at the 5% level of probability.

Figure 2 Effect of antitranspirant, nano-potassium and shading on grape vine yield.

Berries chemical Traits:

Total soluble solids (TSS) differed significantly due to the treatment effects (Table 5), the control recorded the maximum significant value which was (22.57%) followed by the application of nano-potassium which was (21.87%). Minimum significant value was (17.03%) recorded by (T3) which was a shading application by a green net. These variances may be due to the fact that TSS decline in antitranspirant treated vines may be attributed to a reduction in photosynthetic capacity or/and restraint in the translocation of sugar from leaf to berry (Di Vaio *et al.*, 2019). According to Cataldo *et al.*, (2022) temperatures above 32 °C caused higher TSS due to an increase in suspended content. Potassium has a positive role in the translocation of sugar which is produced by starch hydrolysis from the leaf to fruit, which lead to rise of TSS because a general increase sugar accumulation results high TSS (Kumaran *et al.*, 2019).

The TTA was affected significantly by treatments (Table 5), maximum significant value (0.798%) recorded by T8, lowest significant value (0.590%) which was recorded by T1 (control). These significant differences among treatments may be due to antitranspirant application causes a decrease in CO2 uptake, by layering a film on the leaf surfaces, which finally results in delaying sugar accumulation in fruit and total acidity still high (Silvestroni *et al.*, 2020). Shading results in cooling in the vine and as described by (Parker *et al.*, 2015) there is a negative correlation between temperature and TTA, which means increasing temperature caused a reduction in TTA.

Total carotenoid content in grape berries showed significant differences resulting from the experiment treatments antitranspirant, nano-potassium and shading (Table 5). Untreated grape resulted in the maximum significant increases among treatments which was (1.40 µg g^{-1} FW) followed by the treatment number three which was nano-potassium application and it recorded (1.28 µg g^{-1} FW). The lowest value was (0.70 µg g^{-1} FW) obtained by (T8). This improvement in grape carotenoid in stress condition may be due to the fact that one of the important non-enzymatic antioxidants is carotenoids, it is acting a vital role in response to various stress conditions. Consequently, their ratio and level may rise as a response to drought stress (Jaleel *et al.,* 2009; Young & Lowe, 2018 and Kovalikova *et al.,* 2020). Under water stress, the chlorophyll content reduces under water stress (Table 3), this reduction may be attributed to increase reactive

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oxygen species production, which results in the breakdown of these pigments. Carotenoids act as chlorophyl protector from photooxidation (Saedi *et al.*, 2017). This result is in line with (Zonouri *et al.*, 2014) which mentioned that khoshnav grape cultivar in drought stress increase the carotenoid content. The increase of fruit carotenoid content resulting from nano-potassium application may be due to that described by (Kohli *et al.*, 2019) that potassium led to a rise carotenoid content by enhancing protein in thylakoid membrane. As anticipated, from the researchers monitoring that sunlight may be promote photosystem II function in plants, thus, carotenoid biosynthesis (Albrecht & Sandmann, 1994). Inversely, shading reduced sunlight and consequentially decline carotenoid.

Also, anthocyanin content in grape berries recorded significant differences among the research treatments at $p < 0.05$ level (Table 5), maximum significant mean value compared to all other treatments was (2.52 mg $100g^{-1}$ FW) recorded in untreated grape, second significant mean value was (2.34 mg $100g^{-1}$ FW) recorded by grape treated with nano-potassium, the interaction of antitranspirant and shading (T6) gave the lowest significant value which was (1.50 mg $100g^{-1}$ FW). These variations in the anthocyanin values may be attributed to the effects of treatments as following, under water stress, the chlorophyll content reduces in drought condition (Table 3), this reduction may be attributed to increased reactive oxygen species production, which results in the breakdown of these pigments. The rise in anthocyanins and carotenoids is a preservative response from the plant, anthocyanins act as important antioxidants to protect plant tissues against oxidative stress by directly scavenging free radicals (Saedi *et al.*, 2017). By using an antitranspirant, the grape berry cell holds utmost water which leads to color dilution and decrease the anthocyanin concentration in red grape cultivars (Fahey & Rogiers, 2019). Hornero-Méndez *et al.*, (2000) explained that the pepper fruits in immature stage are green color, which is due to the chlorophyll pigments. The breakdown of chlorophyll results in a loss of green color, and as the fruit ripens, the color changed to red. Moreover, the TSS number is considered as the degree of grapes maturation, by referring to Table 5 it can be observed that highest values of TSS were recorded by (T1 and T3) treatment respectively, that may be the factor that led to record total anthocyanin in same treatments. (Wu *et al.*, 2021) showed that foliar potassium application on grapes might quicken the ripening. By accumulating a great amount of anthocyanin, the grape berries will be red or black. Generally, anthocyanins are inversely affected by increasing the temperature when the temperature become too high (Palliotti *et al*., 2013; Spayd *et al.*, 2002). On the other hand, (Köse, 2014) showed that shaded plants have lower temperature compared with unshaded plant, which may be the reason for the reduction of anthocyanins. Moreover, anthocyanins are synthesized when the berries of grape arrived at the veraison stage, duration which, any change or few changes in light intensity reduce the accumulation of anthocyanin (Ristic *et al*., 2007). Anthocyanins synthesis and accumulation in red grape can be regulated by the sugar content in grape (Palliotti *et al.*, 2013), and as shown in Figure 2 the sugar values in (T1 and T3) are the highest values which may lead the anthocyanins to be high in these treatments too.

Table 5 Effect of antitranspirant, nano-potassium and shading on some grape berries' chemical parameters.

Treatments	Total Soluble Solids (TSS) (%)	Total Titratable Acid (TA) (%)	Grape Content of Total Carotenoid (µg g^{-1} FW)	Grape Content of Total Anthocyanin (mg $100g^{-1}$ FW)
T1	22.57 a	0.590 f	1.40 a	2.52 a
T2	18.13 c	0.721 c	0.93 de	1.71 c
T3	21.87 ab	0.717 cd	1.28 ab	2.34 b

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T4	17.03 c	0.761 b	0.77 ef	1.75 c
T5	18.73 bc	0.699 e	1.15 bc	1.80 c
T6	19.73 abc	0.708de	1.02 cd	1.50 d
T7	17.73 c	0.711 cde	1.08 cd	1.77 c
T8	17.40 c	0.798 a	0.70 f	1.73 c

T1 = Control, T2 = Antitranspirant, T3 = Nano potassium fertilizer, T4 = Shading, T5 = Antitranspirant + Nano potassium fertilizer, T6 = Antitranspirant + Shading, T7 = Nano potassium fertilizer + Shading and T8 = Antitranspirant + Nano potassium fertilizer + Shading.
Means within each column followed by different letters differ significantly according to Duncan's multiple range test at the 5% level of probability.

The effects of antitranspirant, nano-potassium and shading on grape and leaves total soluble sugar content are shown in Figure 3, the treatments effects significantly on grape berries total soluble sugar content; the maximum significant value was 1321.36 µg g^{-1} FW recoded by the control, furthermore, second significant value was (1313.42 µg g^{-1} FW) recorded by nano-potassium application (T3). In contrast, the minimum significant value was (806.23 µg g^{-1} FW) recorded by (T6) which was the interaction between antitranspirant and shading. In (Figure 3) the antitranspirant (T2) and shading (T4) application individually recorded the mean values lower than control and may be the interaction between them lead to more increase in total soluble sugar content. By using antitranspirant the grape berry cell holding utmost water which lead to sugar dilution and decrease the sugar concentration (Fahey & Rogiers, 2019) or CO_2 uptake was reduced due to the permeability of the film-forming which, which cause, retard sugar accumulation (Silvestroni *et al.*,2020). Anthocyanins synthesis and accumulation in red grape can be regulated by the sugar content in grape (Palliotti *et al.*, 2013), and as shown in Figure 2 the sugar values in (T1 and T3) are the highest value which may be lead the anthocyanins are be high in these treatments too. On another hand, one of TSS component is sugar, and as shown in Table 5 the TSS value in antitranspirant application (T2) was lower than (T1 and T3) and higher compared to (T4). Antitranspirants applications demonstrate opposed results regarding to their effects on grape anthocyanins conte1nt. Some researchers showed a significant rise in the grape anthocyanin content has been recorded by (Palliotti *et al.*, 2010; Gatti *et al.*, 2016 and Di Vaio *et al.*, 2019). In contrast, a decline in the concentration of anthocyanin after antitranspirants application was observed by (Palliotti *et al.*, 2013 and Brillante *et al.*, 2016), or a delayed berries coloration (Zhang *et al.*, 2017). Before veraison stage, potassium could contribute to inner sugar dealing out in plants and later accumulate in the cell vacuole with begins the grape maturity. Moreover, potassium also possesses a role in synthesis the carbohydrate and also translocation it increases as a result grape soluble solids content which may explain the rising sugar content in grape berries (Rogiers *et al.*, 2017 and Benmoussa & Ben Mimoun, 2025). Guérios *et al.* (2021) declare that shading had significantly lessen sugar accumulation and delayed the maturation of fruit.

Figure 2 showed the significant effect of the treatments on leaves total soluble sugar content, according to the figure, generally the two line of soluble sugar content are nearly show parallel line with different values. Maximum significant mean value was (313.83 µg g^{-1} FW) recorded by control followed by (T3) which gave (292.33 µg g^{-1} FW). Minimum significant mean values were (209.01 and 213.52 µg g^{-1} FW) recorded by (T4 and T8) respectively. Near fruits ripening the plant demand to potassium increasing, and may be due to that potassium application which lead to improve the process of nutrient uptake in the fruit and increase the sugar content (Wang *et al.*, 2024).

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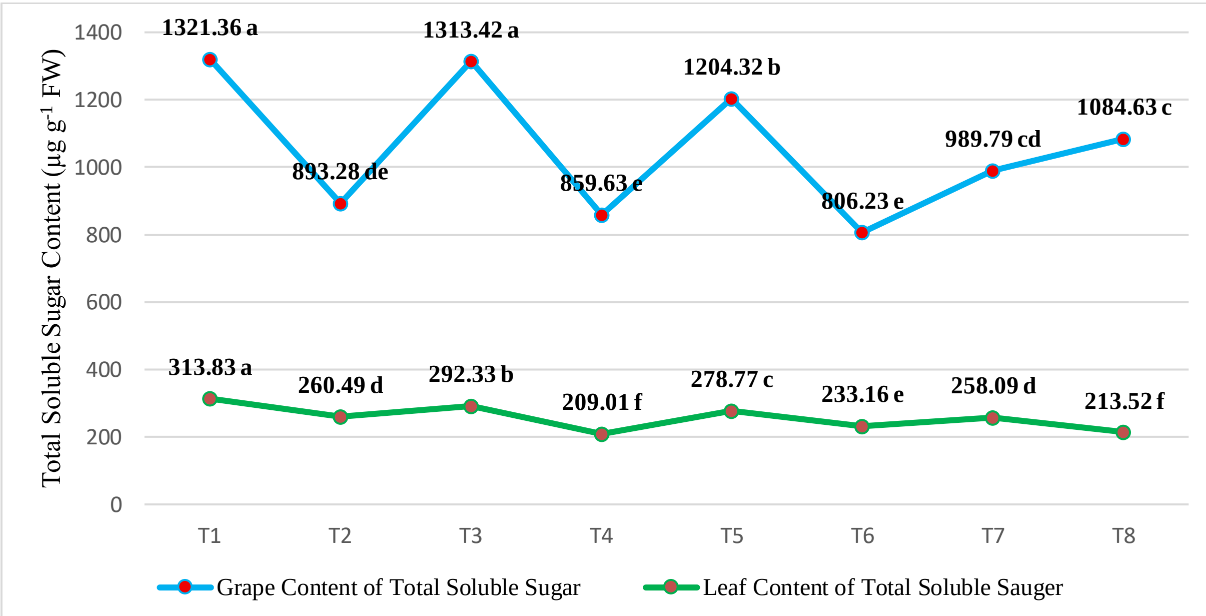

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Means within each column followed by different letters differ significantly according to Duncan's multiple range test at the 5% level of probability.

Figure 3 Effect of antitranspirant, nano-potassium and shading on grape and leaves total soluble sugar content.

Effect of the antitranspirant, nano-potassium and shading on grape and leaves total phenolic content shown in Figure 4, significant differences among the means values of total phenolic content in leaf berries were observed. The highest value of total phenolic content in leaf was (907.08 µg g^{-1} FW) recorded by nano-potassium application treatment (T3), the second high value was (897.20 µg g^{-1} FW) recorded by the control treatment (T1). In our results, total phenolic content in the grape berries of shaded vine gave the lowest value which was (560.16 µg g^{-1} FW). These variations among the mean values of treatments may be due to that illustrated by many researchers, which describe that under different abiotic stresses conditions the phenols production in plant tissues increased (Król *et al.*, 2014). The increase of phenolics and flavonoids and under severe water limiting stress is linked to the cumulation of soluble carbohydrates in plant tissue in order to reduce the transportation of soluble sugar among the plant parts under drought stress condition (Gharibi *et al.*, 2016). It is obvious that an increased in light radiation and due to rise the stress on plant lead to accumulation more phenol and flavonoid in leaves and berry skin (Oliveira *et al.*, 2014 and Miccichè *et al.*, 2023).

Research treatments led to recorded significant variations among mean values of grape total phenolic content, with nano-potassium spray the maximum mean value was recorded (188.76 µg g^{-1} FW), followed by (185.17 µg g^{-1} FW) which

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recorded by control. With shading vine lowest grape total phenolic content which was (122.85 µg g^{-1} FW). Previous research such as Irani *et al.* (2021) illustrated that phenolic compounds consider from a category of nonenzymatic antioxidant systems operate in plants cells with abiotic stresses. Moreover, Wróbel *et al.* (2005) explain that phenols production in plant cell may be rise under different abiotic stresses conditions. Environmental stress can cause a grow (Al Hassan *et al.*, 2015 and Gharibi *et al.*, 2016) or a reduction (Weidner *et al.*, 2007 and Krol *et al.*, 2014) in the total phenolic content of plants. These variance in results may be due to that many phytochemicals accumulation in plants, their degree are affected by alteration in temperature, water availability and light, as these environmental traits vary both around the day and year, also by seasonal variation and geographical locations and the more important factor is plant genetic (Liebelt *et al.*, 2019 and Jadaun *et al.*, 2023). Anthocyanins are considered as the most plentiful phenolic compounds in black grapes, accounting for more than half of the total of phenolic compounds are anthocyanins (Pérez-Álvarez *et al.*, 2021), and is clear from Table 5 the highest values of anthocyanins recorded by (T1 and T3) also same treatments was recorded maximum total phenolic content (Figure 4).

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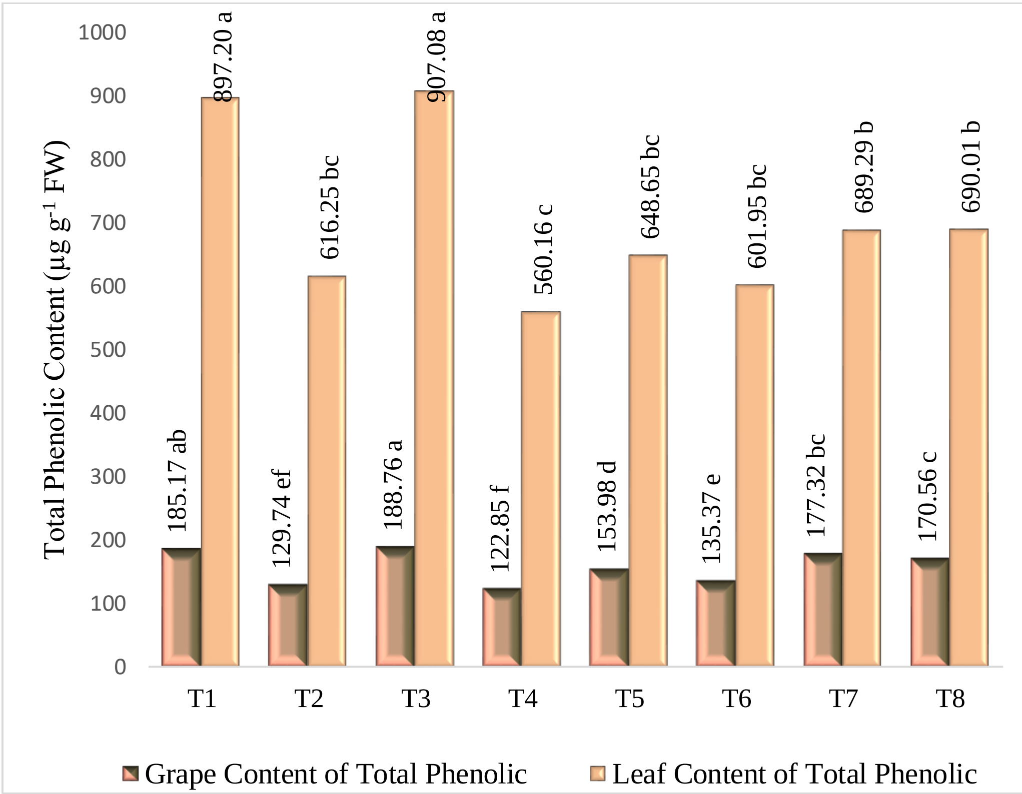

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Means within each column followed by different letters differ significantly according to Duncan's multiple range test at the 5% level of probability.

Figure 4 Effect of antitranspirant, nano-potassium and shading on grape and leaves total phenolic content.

Antitranspirant, nano-potassium and vine shading have significant effects on grape and leaves total flavonoids content (Figure 5). In Tre-rash cultivar, the results of estimating the total flavonoids in leaf showed that the treatments have significant effects, the highest value was (430.67 µg QE g^{-1} FW) recorded by (T1), followed by (T3) which gave (427.04 µg QE g^{-1} FW) the both treatments are significant compared to other treatments, lowest significant value was (225.81 µg QE g^{-1} FW) recorded by (T6).

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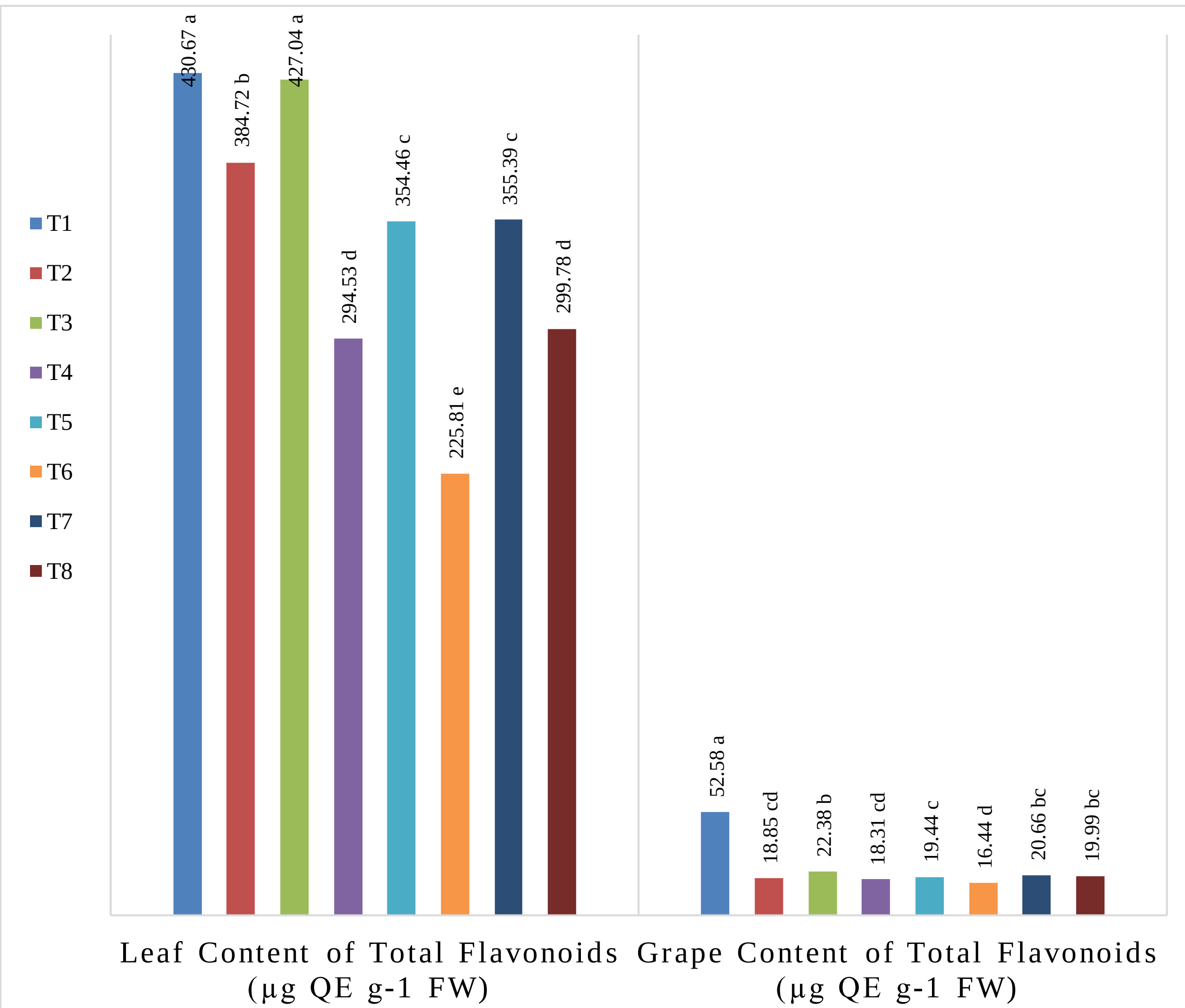
The mean values of total flavonoid content in grape also differ significantly, maximum value was (52.58 µg QE g^{-1} FW) recorded by untreated vine (T1), followed by nano- potassium application (T3) with value (22.38 µg QE g^{-1} FW). Minimum significant value (16.44 µg QE g^{-1} FW) was recorded by the interaction of spray antitranspirant on shaded vine (T6). These variations in the total flavonoids content in grape and leaves may be due to that in water stress condition, decrease canopy growth, resulted to more exposure of grape clusters to sunlight. Flavanols biosynthesis is especially receptive to sun light and UV exposure, the final result flavonoids accumulation (Gambetta *et al.*, 2020). Using both shading with antitranspirant on grapevine reduce the leaf temperature about 5°C compared to control (Cataldo *et al.*, 2022), this increase in temperature may be reduce the effect of stress and lowering the concentration of those phytochemicals which rise in stress conditions.



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Means within each column followed by different letters differ significantly according to Duncan's multiple range test at the 5% level of probability.

Figure 5 Effect of antitranspirant, nano-potassium and shading on grape and leaves total flavonoids content.

From the data arranged (Figure 6) we conclude that grape leaf proline was affected significantly by treatments, maximum significant value of grape leaf proline content was (3764.51 µg g^{-1} FW) recorded by control (T1), lowest significant value of grape leaves proline content was (2615.79 µg g^{-1} FW) recorded when the grapevine treated by antitranspirant, nano-potassium and shading by green net (T8). These recorded variances among the treatment mean values may be due to that suggest by Seidi *et al.* (2025) that the proline content in leaves is a prevalent adaptive strategy of plants against stress, while proline acts a significant role in several physiological processes such as membrane stabilization, antioxidant defense and osmoregulation.

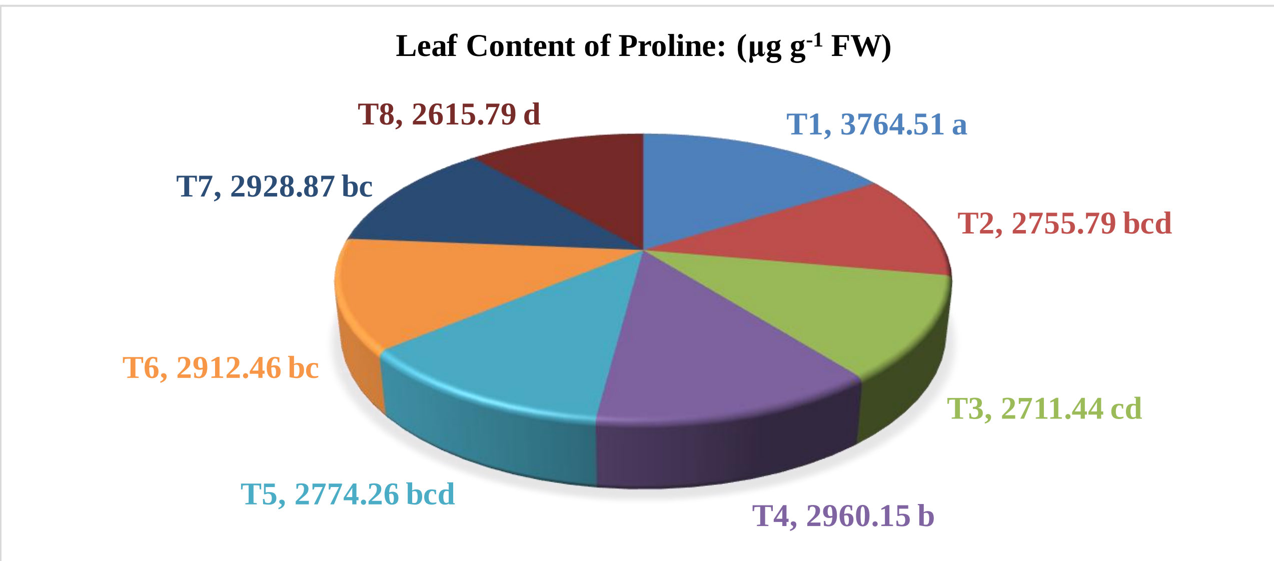

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Figure 6 Effect of antitranspirant, nano-potassium and shading on grape leaf content of proline.

The used treatments (antitranspirant, nano-potassium and shading) recorded significant differences among means values of grapevine leaves lipid peroxidation content at $p < 0.05$ level Figure 7, maximum value which recorded by untreated grape vine was (3.72 nmol g^{-1}) this treatment was significantly compared to all other treatments which were no significant differences observed among them, minimum value (2.44 nmol g^{-1}) recorded by the interaction among the three factors of the experiment. These variance amid the mean values of lipid peroxidation content in grape vine may be due to that under severe drought conditions, surplus ROS production in the cell of the plants can overstate cellular lipid peroxidation, causing to a rise in the cell membrane permeability, which is indicate by grow in the electrolyte leakage and malondialdehyde content, potassium is actively reducing lipid peroxidation which accumulate as a result to drought (Mirza *et al.*, 2019). Moreover, drought stress causes oxidative stress in leaves, leading to the production of reactive oxygen species (ROS) resulting to the peroxidation of lipid in cell membranes which means cell membrane damage (Mihaljević *et al.*, 2021)

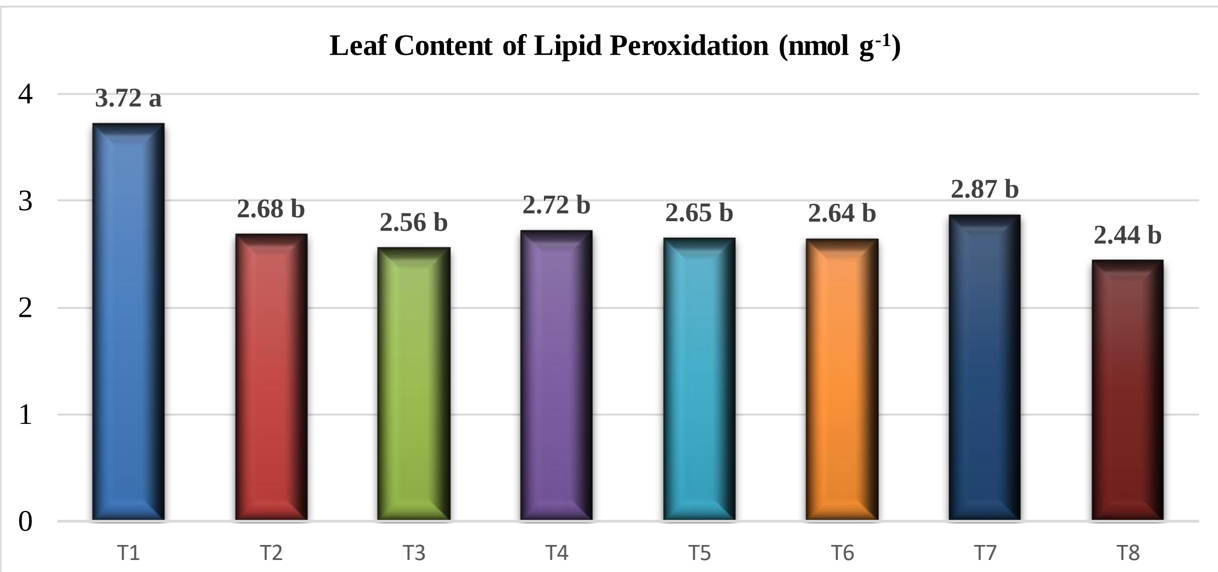

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Figure 7 Effect of antitranspirant, nano-potassium and shading on grape leaf content of lipid peroxidation.

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IV. Conclusion

The obtained results illustrate that the use of the treatments, plant anti-transpiration, nano-potassium fertilizer, and shading by net exerted significant influences on various vine vegetative traits, grape quality attributes, and total vine yield. These findings suggested that, even though the phytochemical results propose the Tre-Rash grape cultivar possesses distinct apparatus for tolerance to drought and heat stress, proven external factors can further improve physiological activity under water-deficit conditions. It is subsequently recommended that the combined use of such protective treatments may enhance plant resilience and productivity under drought stress.

V. References

Abdallah, M. M. S., El-Bassiouny, H. M. S., & AbouSeeda, M. A. (2019). Potential role of kaolin or potassium sulfate as anti-transpirant on improving physiological, biochemical aspects and yield of wheat plants under different watering regimes. *Bulletin of the National Research Centre*, 43(1), 134.

Abiri, K., Rezaei, M., Tahanian, H., Heidari, P., & Khadivi, A. (2020). Morphological and pomological variability of a grape (*Vitis vinifera* L.) germplasm collection. *Scientia Horticulturae*, *266*, 109285.

Al Hassan, M., Fuertes, M. M., Sánchez, F. J. R., Vicente, O., & Boscaiu, M. (2015). Effects of salt and water stress on plant growth and on accumulation of osmolytes and antioxidant compounds in cherry tomato. *Notulae Botanicae Horti Agrobotanici Cluj-Napoca*, 43(1), 1-11.

Albrecht, M., & Sandmann, G. (1994). Light-stimulated carotenoid biosynthesis during transformation of maize etioplasts is regulated by increased activity of isopentenyl pyrophosphate isomerase. *Plant physiology*, 105(2), 529.

Albrizio, R., Puig-Sirera, À., Sellami, M. H., Guida, G., Basile, A., Bonfante, A., ... & Giorio, P. (2023). Water stress, yield, and grape quality in a hilly rainfed "Aglianico" vineyard grown in two different soils along a slope. *Agricultural Water Management*, 279, 108183.

Alharbi, K., Alnusairi, G. S., Alnusaire, T. S., Alghanem, S. M., Alsudays, I. M., Alaklabi, A., & Soliman, M. H. (2024). Potassium silica nanostructure improved growth and nutrient uptake of sorghum plants subjected to drought stress. *Frontiers in Plant Science*, *15*, 1425834.

Al-Jubori, Y. M. S. (2023). *Effect of fertilization with conventional, nano NPK and nano chelated zinc on growth and yield of Kamali and Taifi grape cultivars*. Doctoral dissertation, University of Mosul College of Agriculture and Forestry, Iraq.

Al-Quraishi, A. M. F & Negm A. M. (Eds.). (2020). Environmental Remote Sensing and GIS in Iraq. Springer.

Al-Rawi, K. M., & Khalafalla, A. (2000). Analysis of Experimental Agriculture Design. Dar Al-Kutub for Printing and Publishing. Mosul University.

ISSN Onlin:2708-9347, ISSN Print: 2708-9339 Volume 14, Issue 2 (2025) PP 340-362
https://jam.utq.edu.iq/index.php/main *https://doi.org/10.54174/utjagr.v13i1.323*

Al-Saidi, 2000, I. H. M. (2000). *Grape production*. Ministry of Higher Education and Scientific Research - University of Mosul.

Bayraktar, T. U., Bayraktar, Ö. V., & Solak, M. (2025). Optimizing Artificial Shading for Microclimate, Yield, Leaf Nutrient and Economic Benefits in Sinceri (V. vinifera L.) Grape Cultivation. *Turkish Journal of Agriculture-Food Science and Technology*, *13*(3), 656-663.

Begna, T. (2020). Effects of drought stress on crop production and productivity. *International Journal of Research Studies in Agricultural Sciences*, *6*(9), 34-43.

Benmoussa, H., & Ben Mimoun, M. (2024, February). Effect of potassium thiosulfate on 'Muscat of Italy' grape yield and quality. In *V All Africa Horticultural Congress-AAHC2024 1422*, 21-28.

Brillante, L., Belfiore, N., Gaiotti, F., Lovat, L., Sansone, L., Poni, S., & Tomasi, D. (2016). Comparing kaolin and pinolene to improve sustainable grapevine production during drought. *PLoS One,* 11(6), e0156631.

Caravia, L., Collins, C., Petrie, P. R., & Tyerman, S. D. (2016). Application of shade treatments during Shiraz berry ripening to reduce the impact of high temperature. *Australian Journal of Grape and Wine Research*, *22*(3), 422-437.

Cataldo, E., Fucile, M., & Mattii, G. B. (2022). Effects of kaolin and shading net on the ecophysiology and berry composition of sauvignon blanc grapevines. *Agriculture*, *12*(4), 491.

Chacón-Vozmediano, J. L., Martínez-Gascueña, J., García-Navarro, F. J., & Jiménez-Ballesta, R. (2020). Effects of water stress on vegetative growth and 'merlot'grapevine yield in a semi-arid mediterranean climate. *Horticulturae*, *6*(4), 95.

Di Vaio, C., Marallo, N., Di Lorenzo, R., & Pisciotta, A. (2019). Anti-transpirant effects on vine physiology, berry and wine composition of cv. Aglianico (Vitis vinifera L.) grown in south Italy. *Agronomy*, 9(5), 244.

Dinis, L. T., Bernardo, S., Matos, C., Malheiro, A., Flores, R., Alves, S., ... & Moutinho-Pereira, J. (2020). Overview of Kaolin Outcomes from vine to wine: Cerceal white variety case study. *Agronomy*, *10*(9), 1422.

Fahey, D. J., & Rogiers, S. Y. (2019). Di-1-p-menthene reduces grape leaf and bunch transpiration. Australian. *Journal of Grape and Wine Research*, 25(1), 134-141.

Freeman, B. M., Lee, T. H., & Turkington, C. R. (1979). Interaction of irrigation and pruning level on growth and yield of Shiraz vines. *American Journal of Enology and Viticulture*, 30(3), 218-223.

Gambetta, G. A., Herrera, J. C., Dayer, S., Feng, Q., Hochberg, U., & Castellarin, S. D. (2020). The physiology of drought stress in grapevine: towards an integrative definition of drought tolerance. *Journal of experimental botany, 7*1(16), 4658-4676.

Gatti, M., Galbignani, M., Garavani, A., Bernizzoni, F., Tombesi, S., Palliotti, A., & Poni, S. (2016). Manipulation of ripening via antitranspirants in cv. B arbera (V itis vinifera L.). *Australian Journal of Grape and Wine Research*, *22*(2), 245-255.

Gharibi, S., Tabatabaei, B. E. S., Saeidi, G., & Goli, S. A. H. (2016). Effect of drought stress on total phenolic, lipid peroxidation, and antioxidant activity of Achillea species. *Applied biochemistry and biotechnology*, 178(4), 796-809.

Guérios, I. T., Cuquel, F. L., & Biasi, L. A. (2021). Bagging of bunches and protected production in 'Niagara Rosada' vineyard. *Pesquisa Agropecuária Gaúcha*, 27(1), 90-98.

Hornero-Méndez, D., Gómez-Ladrón de Guevara, R., & Minguez-Mosquera, M. I. (2000). Carotenoid biosynthesis changes in five red pepper (Capsicum annuum L.) cultivars during ripening. Cultivar selection for breeding. *Journal of Agricultural and Food Chemistry*, 48(9), 3857-3864.

Hussein, S. A., Kanber, H. S., & Lateef, M. A. A. (2022). Growth regulator's role on the growth and yield of grapes (Vitis vinifera L.): A review. *European Journal of Research Development and Sustainability*, *3*(2), 85-88.

Irani, H., ValizadehKaji, B., & Naeini, M. R. (2021). Biostimulant-induced drought tolerance in grapevine is associated with physiological and biochemical changes. *Chemical and Biological Technologies in Agriculture*, 8(1), 1-13.

Jadaun, J. S., Yadav, R., Yadav, N., Bansal, S., & Sangwan, N. S. (2023). Influence of Genetics on the secondary metabolites of plants. In *Natural secondary metabolites: from nature, through Science, to industry* (pp. 403-433). Cham: Springer International Publishing.

Jaleel, C. A., Manivannan, P, Wahid, A., Farooq, M., Al-Juburi, H. J., Somasundaram, R., & Panneerselvam, R. (2009). Drought stress in plants: a review on morphological characteristics and pigments composition. *Int. J. Agric. Biol*, 11(1), 100-105.

Kohli, S. K., Khanna, K., Bhardwaj, R., Abd_Allah, E. F., Ahmad, P., & Corpas, F. J. (2019). Assessment of subcellular ROS and NO metabolism in higher plants: multifunctional signaling molecules. *Antioxidants*, 8(12), 641.

Köse, B. (2014). Effect of light intensity and temperature on growth and quality parameters of grafted vines. *Notulae Botanicae Horti Agrobotanici Cluj-Napoca*, *42*(2), 507-515.

Kovalikova, Z., Jiroutova, P., Toman, J., Dobrovolna, D., & Drbohlavova, L. (2020). Physiological responses of apple and cherry in vitro culture under different levels of drought stress. *Agronomy*, 10(11), 1689.

Król, A., Amarowicz, R., & Weidner, S. (2014). Changes in the composition of phenolic compounds and antioxidant properties of grapevine roots and leaves (Vitis vinifera L.) under continuous of long-term drought stress. *Acta Physiologiae Plantarum*, 36(6), 1491-1499.

Kumaran, P. B., Venkatesan, K., Subbiah, A., & Chandrasekhar, C. N. (2019). Effect of pre-harvest foliar spray of potassium schoenite and chitosan oligosaccharide on yield and quality of grapes var. Muscat Hamburg. *International Journal of Chemical Studies*, 7(3), 3998-4001.

Li, W., Yao, H., Chen, K., Ju, Y., Min, Z., Sun, X., ... & Fang, Y. (2021). Effect of foliar application of fulvic acid antitranspirant on sugar accumulation, phenolic profiles and aroma qualities of Cabernet Sauvignon and Riesling grapes and wines. *Food Chemistry*, *351*, 129308.

Liebelt, D. J., Jordan, J. T., & Doherty, C. J. (2019). Only a matter of time: the impact of daily and seasonal rhythms on phytochemicals. *Phytochemistry Reviews*, 18(6), 1409-1433.

Mahmood, A. M. R., Kasnazany, S. A. S., Mirza, A. N., & Omer, H. A. (2022). Evaluation of some physical and chemical characteristics of two grape cultivars under irrigated and non-irrigated conditions. *Journal of Kerbala for Agricultural Sciences*, *9*(4), 98-117.

ISSN Onlin:2708-9347, ISSN Print: 2708-9339 Volume 14, Issue 2 (2025) PP 340-362
https://jam.utq.edu.iq/index.php/main *https://doi.org/10.54174/utjagr.v13i1.323*

Miccichè, D., de Rosas, M. I., Ferro, M. V., Di Lorenzo, R., Puccio, S., & Pisciotta, A. (2023). Effects of artificial canopy shading on vegetative growth and ripening processes of cv. Nero d'Avola (*Vitis vinifera* L.). *Frontiers in Plant Science*, *14*, 1210574.

Miccichè, D., Puccio, S., Di Lorenzo, R., Turano, L., Di Carlo, F., & Pisciotta, A. (2025). Adapting Viticulture to Climate Change: Impact of Shading in Sicily. *Horticulturae*, *11*(2).

Mihaljević, I., Viljevac Vuletić, M., Šimić, D., Tomaš, V., Horvat, D., Josipović, M., ... & Vuković, D. (2021). Comparative study of drought stress effects on traditional and modern apple cultivars. *Plants*, 10(3), 561.

Mirza, H., Khalid, R. H., Kamrun, N., & Hesham, F. A. (2019). Plant abiotic stress: tolerance agronomic, molecular and biotechnological approaches.

Moghith, W. M. (2024). Influence of different irrigation intervals and anti-transpiration compounds on productivity and chemical constituents of echinacea purpurea l. plant. *Egyptian Journal of Desert Research, 74*(2), 277-291.

Oliveira, M., Teles, J., Barbosa, P., Olazabal, F., & Queiroz, J. (2014). Shading of the fruit zone to reduce grape yield and quality losses caused by sunburn. *OENO One*, *48*(3), 179-187.

Palliotti, A., Panara, F., Famiani, F., Sabbatini, P., Howell, G. S., Silvestroni, O., & Poni, S. (2013). Postveraison application of antitranspirant di-1-p-menthene to control sugar accumulation in Sangiovese grapevines. *American Journal of Enology and Viticulture*, *64*(3), 378-385.

Palliotti, A., Poni, S., Berrios, J. G., & Bernizzoni, F. (2010). Vine performance and grape composition as affected by early-season source limitation induced with anti-transpirants in two red Vitis vinifera L. cultivars. *Australian Journal of Grape and Wine Research*, *16*(3), 426-433.

Palliotti, A., Tombesi, S., Silvestroni, O., Lanari, V., Gatti, M., & Poni, S. (2014). Changes in vineyard establishment and canopy management urged by earlier climate-related grape ripening: A review. *Scientia Horticulturae*, *178*, 43-54.

Pallotti, L., Partida, G., Laroche-Pinel, E., Lanari, V., Pedroza, M., & Brillante, L. (2025). Late-season source limitation practices to cope with climate change: delaying ripening and improving colour of Cabernet-Sauvignon grapes and wine in a hot and arid climate. *OENO One*, *59*(1).

Parker, A. K., Hofmann, R. W., Van Leeuwen, C., McLachlan, A. R., & Trought, M. C. (2015). Manipulating the leaf area to fruit mass ratio alters the synchrony of total soluble solids accumulation and titratable acidity of grape berries. *Australian Journal of Grape and Wine Research,* 21(2), 266-276.

Pérez-Álvarez, E. P., Intrigliolo, D. S., Almajano, M. P., Rubio-Bretón, P., & Garde-Cerdán, T. (2021). Effects of water deficit irrigation on phenolic composition and antioxidant activity of Monastrell grapes under semiarid conditions. *Antioxidants*, 10(8), 1301.

Qiu, T., Wu, Y., Shen, Z., Wu, Y., Lu, D., & He, J. (2018). Effects of shading on leaf physiology and morphology in the 'Yinhong'grape plants. *Revista Brasileira de Fruticultura*, *40*(5), e-037.

Ranganna, S. (2011). *Handbook of Analysis and Quality Control for Fruit and Vegetable Products*. 2nd edition, New Delhi, McGrow-Hill.

Rasul, K. S. (2023). *Response of different tomato accessions to biotic and abiotic stresses*. Doctoral dissertation, University of Sulaimani. College of Agricultural Engineering Sciences. Kurdistan Regional Government. Iraq.

Rigane, G., Ghazghazi, H., Aouadhi, C., Ben Salem, R. and Nasr, Z. (2017). Phenolic content, antioxidant capacity and antimicrobial activity of leaf extracts from Pistacia atlantica. *Natural product research*, 31(6), 696–699.

Ristic, R., Downey, M. O., Iland, P. G., Bindon, K., Francis, I. L., Herderich, M., & Robinson, S. P. (2007). Exclusion of sunlight from Shiraz grapes alters wine colour, tannin and sensory properties. *Australian Journal of Grape and Wine Research*, 13(2), 53-65.

Rogiers, S. Y., Coetzee, Z. A., Walker, R. R., Deloire, A., & Tyerman, S. D. (2017). Potassium in the grape (Vitis vinifera L.) berry: transport and function. *Frontiers in plant science*, 8, 1629.

Rolle, L., Siret, R., Segade, S. R., Maury, C., Gerbi, V., & Jourjon, F. (2012). Instrumental texture analysis parameters as markers of table-grape and winegrape quality: A review. *American Journal of Enology and Viticulture*, 63(1), 11-28.

Romero, P., Acosta, J. M. N., Pérez-Pérez, J. G., Dodd, I. C., Antolinos, V., Marín, J. L., Saavedra, F. DA., E.M., & Ordaz, P. B. (2025). The rootstock imparts different drought tolerance strategies in long-term field-grown deficit irrigated grapevines. *Scientia Horticulturae*, *346*, 114167.

Saedi, F., Mosavi Nik, S. M., & Rahimian Boger, A. R. (2017). Effects of different fertilizers on the morphophysiological characteristics of chicory under drought stress. *Journal of Crops Improvement*, 19(1), 119-132.

Santesteban, L. G., Miranda, C., & Royo, J. B. (2011). Regulated deficit irrigation effects on growth, yield, grape quality and individual anthocyanin composition in Vitis vinifera L. cv.'Tempranillo'. *Agricultural Water Management*, 98(7), 1171-1179.

Shellie, K. C. (2014). Water productivity, yield, and berry composition in sustained versus regulated deficit irrigation of Merlot grapevines. *American Journal of Enology and Viticulture*, 65(2), 197-205.

Silvestroni, O., Lanari, V., Lattanzi, T., Dottori, E., & Palliotti, A. (2020). Effects of anti-transpirant di-1-p-menthene, sprayed post-veraison, on berry ripening of Sangiovese grapevines with different crop loads. *Australian Journal of Grape and Wine Research*, *26*(4), 363-371.

Spayd, S. E., Tarara, J. M., Mee, D. L., & Ferguson, J. C. (2002). Separation of sunlight and temperature effects on the composition of Vitis vinifera cv. Merlot berries. *American journal of enology and viticulture*, 53(3), 171-182.

Taiz, L., & Zeiger, E. (2010). *Plant physiology*, 5th ed. Sunderland. MA: Sinauer Associates.

Torres, N., Martínez-Lüscher, J., Porte, E., & Kurtural, S. K. (2020). Optimal ranges and thresholds of grape berry solar radiation for flavonoid biosynthesis in warm climates. *Frontiers in plant science*, *11*, 931.

Villette, J., Cuéllar, T., Verdeil, J. L., Delrot, S., & Gaillard, I. (2020). Grapevine potassium nutrition and fruit quality in the context of climate change. *Frontiers in Plant Science*, 11, 123.

Wang, Q., Liao, Y., Zhao, W., Yi, T., Jiang, Y., Zhu, G., ... & Rui, Y. (2024). Potassium-based nanomaterials significantly enhance nutrient utilization efficiency and promote high crop yields. *Environmental Science: Nano, 11*(7), 2906-2922.

Weidner, S., Karamać, M., Amarowicz, R., Szypulska, E., & Gołgowska, A. (2007). Changes in composition of phenolic compounds and antioxidant properties of Vitis amurensis seeds germinated under osmotic stress. *Acta Physiologiae Plantarum*, 29(3), 283-290.

Wróbel, M., Karama, M., Amarowicz, R., Fr czek, E., & Weidner, S. (2005). Metabolism of phenolic compounds in Vitis riparia seeds during stratification and during germination under optimal and low temperature stress conditions. *Acta Physiologiae Plantarum*, 27(3), 313-320.

Wu, L., Li, P., Jia, H., Phillip, F. O., Bao, X., Zhao, F., ... & Yu, K. (2021). The effect of foliar application of k2so4 or kh2po4 on skin color of the 'Kyoho'grape. *Agronomy*, 11(11), 2361.

Young, A. J., & Lowe, G. L. (2018). Carotenoids—antioxidant properties. *Antioxidants*, 7(2), 28.

Zahedi, S. M., Karimi, M., Venditti, A., Zahra, N., Siddique, K. H., & Farooq, M. (2025). Plant adaptation to drought stress: The role of anatomical and morphological characteristics in maintaining the water status. *Journal of Soil Science and Plant Nutrition*, *25*(1), 409-427.

Zhang, Y., Perez, J. C., & Keller, M. (2016). Grape berry transpiration: determinant factors, developmental changes, and influences on berry ripening. *Acta Horticulturae,* 1188, 51-56.

Zonouri, M., Javadi, T., Ghaderi, N., & Saba, M. K. (2014). Effect of foliar spraying of ascorbic acid on chlorophyll a, chlorophyll b, total chlorophyll, carotenoids, hydrogen peroxide, leaf temperature and leaf relative water content under drought stress in grapes. *Bull Environ Pharmacol Life Sci*, 3, 178-184.

Zulkarnaini, Z. M., Sakimin, S. Z., Mohamed, M. T. M., Jaafar, H. B., Amnah, S., & Mellisa. (2020). Anti-transpirant application improves the drought tolerance of fig (*Ficus carica* L.) under optimization of brassinolide. *Asian J Crop Sci*, 12(1), 1-11.