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Exogenous of 28-Homobrassinolide and Salicylic acid Treatments to Improve Fruit Quality and Photosynthesis of Table Grapes (Vitis vinifera L.) cv. Crimson Seedless.

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Abstract

Our study was performed on 6 years old own rooted "Crimson" seedless grapevines during 2023 and 2024 respectively. Sixteen vines uniformly were selected and sprayed two times during the pre-harvest at ten days before veraison stage and at 15 – 20 % coloration. By following treatments: water as (the control), Salicylic acid (SA) at (75 ppm), 28-Homobrassinolide (28-BR) at (0.4 ppm) and Salicylic acid (SA) at (75 ppm) combined with 28-Homobrassinolide (28-BR) at (0.4 ppm). The results indicated that treatment of Salicylic acid (SA) at (75 ppm) combined with 28-Homobrassinolide (28-BR) at (0.4 ppm) Resulted in a significant increase in concentrations of anthocyanin and carotene contents. Moreover, total soluble solid and total soluble solid / acidity (Brix) where shown with high concentration and lowest concentration of Chlorophyll a, b and acidity in "Crimson" grape with the same treatment as compared with the control in both seasons. The same treatments resulted in a significant increase in concentrations of Chlorophyll a, b, (a+b) and Total carbohydrates in "Crimson" grape leaves as compared with the control in both seasons. In general, the use of Salicylic acid (SA) at (75 ppm) combined with 28-Homobrassinolide (28-BR) at (0.4 ppm) two times improved quality of "Crimson" seedless fruits and photosynthesis.

Key words
Salicylic acid, 28-Homobrassinolide, Photosynthesis, Fruit Quality.

Introduction

In Egypt, ‘Crimson Seedless’ was evaluated for their suitability to production in different regions of the world. there is an expansion in growing area of ‘Crimson Seedless’ grape to meet demand because the Egyptian grape growers are looking at the potential of a new export window into the European markets in October and early November, in addition to their usual sendings in June and July. Many factors like environmental conditions and plant growth regulators have been controlled grape berries coloration (shehata, 2024).

Anthocyanins are synthesized by phenylpropanoid and flavonoid pathway in grapes and responses for grape coloration (Ju et al., 2019). Anthocyanins in grapes are effected by some factors, including the genotype, environmental conditions, fertilization, canopy training systems, plant growth regulators, irrigation, and crop-level modifications (Duan et al., 2019; Shehata, 2024; Yue et al., 2021).

Salicylic acid (SA) is classified as a growth promoter and is a naturally occurring phenolic plant growth regulator. It has been found to be crucial in regulating plant vigour, growth, and development under biotic and abiotic stressors (Hayat et al., 2010).

Applying SA foliar treatment to 'Sahebi' grapes pre-veraison enhanced the content of anthocyanins at harvest, especially malvidin-3-glucoside, the cultivar's main anthocyanin, in addition to total phenolics and flavonoids (Oraei et al., 2019).

Even at very low concentrations, brassinosteroids (BRs), a sterol phytohormone, have positive impacts on plant development and stress resistance (Sun et al., 2020). According to Vergara et al. (2018), exogenous treatments of several BRs analogues to "Redglobe" grape clusters result in an increase in the berries' colour, soluble solids content, and total anthocyanins as well as a significant change in the distribution of anthocyanin groups. Clarifying the regulatory effects of twice exogenous salicylic acid (SA) at 75 ppm plus 28-homobrassinolide (28-BR) at 0.4 ppm on anthocyanin production and photosynthesis enhancement was the overall goal of this research.

Materials and Methods

Our study was conducted during two successive seasons 2023 and 2024 on six years old "Crimson" seedless grapevines grown in a private farm at Badr district, El-Beheira governorate. The vines were grown on their own root, spaced at 2 x 3 m, irrigated with drip irrigation system, the vines were uniform, healthy, cane pruned and supported by the gable trellis system. Each vine bore ten canes that were shortened to 10 buds with a total number of clusters adjusted to 40/ vine and regularly received the same horticultural practices adopted in this orchard. Grapevine, distributed over four vines per replication were sprayed to run off using a hand sprayer during the two seasons 2023, 2024, respectively. Treatments were applied in two stages during the pre-harvest at ten days before *veraison* stage and at 15 – 20 % coloration. First picking was done ten days after second. Sixteen vines were selected in a randomized complete block design and the treatments included water as (the control), Salicylic acid (SA) at (75 ppm), 28-Homobrassinolide (28-BR) at (0.4 ppm) and Salicylic acid (SA) at (75ppm) combined with 28-Homobrassinolide (28-BR) at (0.4 ppm). The non-ionic surfactant Tween 80 at 0.05% (v/v) was added to all treatments to reduce the surface tension and to increase the contact angle of sprayed droplets.

Chemical characteristics for berries:

Five bunches were picked from each replicate at harvest time (15, 20 august) during 2023 and 2024 respectively. Then berries were removed from each bunch to determine chemical characteristics.

The percentage of total soluble solids (T.S.S %) in berry juice was measured using a hand-refractometer.

The acidity (%) was determined according to (A.O.A.C., 1985), ratio of TSS to Acidity was calculated.

Chlorophyll a and b (mg 100g-1) and Beta-Carotene (mg 100g-1) were determined according to (Wintermans and Mats, 1965)

Anthocyanin in berry skins (mg/ 100g) was determined according to the method of (Fuleki and Francis, 1968). Chemical characteristics for leaves:

Chlorophyll a and b (mg g-1 F.W) content was estimated as the method described by (Goodwine, 1965). Chlorophyll a + b (mg g-1 F.W) content was calculated.

Total carbohydrates (%) was determind according to (Hedge and Hofreiter, 1962) method.

Statistical Analyses

The experiment was arranged in a completely randomized block design (RCBD) and seven treatments were used (four treatments with four replication). the data was analyzed by using SAS software (SAS, 2000). The least significant differences (LSD) at 5% probability level (Sendercor and Cochran, 1980).

Results

Chemical characteristics of "Crimson Seedless" grape leaves as influenced by pre-harvest treatments were reported in table 1. There were different trend with regard to content of leaves Chlorophyll a since the data showed that within each treatment and even the control the Chlorophyll a was significantly increased with Salicylic acid (SA) at 75 ppm and 28-Homobrassinolide (28-BR) at 0.4 ppm treatments but the highest content of leaves Chlorophyll a was obtained within Salicylic acid (SA) at 75 ppm either plus 28-Homobrassinolide (28-BR) at 0.4 ppm in both seasons compared with control.

Data in table 1 regarding the effect of the various applied treatments on "Crimson" grape leaves Chlorophyll b content. The application of the formulation of Salicylic acid (SA) at 75 ppm either plus 28-Homobrassinolide (28-BR) at 0.4 ppm resulted in high content of leaves Chlorophyll b in both seasons.

In a similar manner, the data in table 1 revealed that content of leaves (Chlorophyll a + b) gave the highest content in Salicylic acid (SA) at 75 ppm either plus 28-Homobrassinolide (28-BR) at 0.4 ppm treatment compared with other treatments and control in both seasons.

With respect to the effect of treatments on total carbohydrates percentage in leaves. It showed that in table 1 treatments of Salicylic acid (SA) at 75 ppm combined with 28-Homobrassinolide (28-BR) at 0.4 ppm was the greatest percentage of total carbohydrates compared with a sole treatment and control in both seasons.

Table 1. Chemical characteristics of "Crimson" grape leaves as influenced by various applied treatments during the two seasons, 2023 and 2024.

Treatments	Chlorophyll a (mg g-1 F.W)		Chlorophyll b (mg g^{-1} F.W)		Chlorophyll (a+b) (mg g^{-1} F.W)		carbohydrates (%)	
	2023	2024	2023	2024	2023	2024	2023	2024
Control	0.63c	0.65d	0.52d	0.48b	1.15c	1.13d	30.20d	32.10c
SA 75 ppm	0.70b	0.72b	0.55c	0.57a	1.25b	1.29b	35.90b	34.50b
28-BR 0.4 ppm	0.68bc	0.69c	0.53b	0.50b	1.21bc	1.19c	34.30c	34.40b
SA 75ppm +28-BR 0.4 ppm	0.77a	0.75a	0.61a	0.59a	1.38a	1.34a	37.90a	35.90a
LSD at 5%	0.07	0.02	0.01	0.02	0.07	0.05	0.23	0.20

Similar letter of each column were not significantly different according to the least significant difference (LSD) at 5% levels.

Pigments of "Crimson Seedless" fruits as influenced by pre-harvest treatments were reported in table 2. The data showed that lowest content of Chlorophyll a and Chlorophyll b at harvest was obtained with the pre-harvest treatment Salicylic acid (SA) at 75 ppm combined with 28-Homobrassinolide (28-BR) at 0.4 ppm as compared with the sole treatment and control in both seasons. Meanwhile, all individual treatments proved to have an effective, significant effect on reducing the Chlorophyll a and Chlorophyll b content of "Crimson Seedless" grape when compared with the control in both seasons.

Anthocyanin and carotene content of "Crimson Seedless" fruits was effected by pre-harvest treatments either Salicylic acid (SA) at 75 ppm, 28-Homobrassinolide (28-BR) at 0.4 ppm as sole treatment or Salicylic acid (SA) at 75 ppm combined with 28-Homobrassinolide (28-BR) at 0.4 ppm in table 2. The combined of Salicylic acid (SA) at 75 ppm and 28-Homobrassinolide (28-BR) at 0.4 ppm was greater the influence on Anthocyanin and carotene content of "Crimson Seedless" fruits than its individual treatments in both seasons compared with control.

Table 2. Pigments of "Crimson" grape as influenced by various applied treatments during the two seasons, 2023 and 2024.

Treatments	Chlorophyll a (mg $100g^{-1}$)		Chlorophyll b (mg $100g^{-1}$)		Carotene (mg $100g^{-1}$)		Anthocyanin (mg $100g^{-1}$)	
	2023	2024	2023	2024	2023	2024	2023	2024
Control	0.95a	1.12a	0.52a	0.44a	0.98d	0.72d	18.73d	25.20d
SA 75 ppm	0.78b	0.77c	0.30c	0.30b	1.39b	1.90b	25.45b	33.98b
28-BR 0.4 ppm	0.75c	0.84b	0.34b	0.32b	1.25c	1.37c	22.80c	28.33c
SA 75ppm +28-BR 0.4 ppm	0.73c	0.74d	0.26d	0.29b	2.86a	2.86a	35.70a	38.10a
LSD at 5%	0.02	0.02	0.02	0.10	0.02	0.10	0.12	0.12

Similar letter of each column were not significantly different according to the least significant difference (LSD) at 5% levels.

With regard to the change in TSS as a result to pre-harvest treatments. The data in table 3 showed that the highest percentage was obtained with the formulation of Salicylic acid (SA) at 75 ppm with 28-Homobrassinolide (28-BR) at 0.4 ppm. Moreover, Salicylic acid (SA) at 75 ppm was able to cause a significant increase in TSS percentage especially in first season compared to the control.

The influence of various used treatments on juice acidity of "Crimson" grape were reported in table 3. The data reported that the magnitudes of reductions in juice acidity by exogenous treatments since the highest acidity percentage were found with the control fruits in both seasons. The highest acidy reduction was found with the used formulation treatments Salicylic acid (SA) at 75 ppm with 28-Homobrassinolide (28-BR) at 0.4 ppm in both seasons compared with sole treatments or control. However, Salicylic acid (SA) at 75 ppm as an individual treatment was able to reduce the juice acidity relative to the control especially in second season.

The influence of field applications of Salicylic acid (SA) at 75 ppm, 28-Homobrassinolide (28-BR) at 0.4 ppm and Salicylic acid (SA) at 75 ppm combined with 28-Homobrassinolide (28-BR) at 0.4 ppm on the TSS to Acidity ratio of "Crimson" grape were reported in table 3. The data revealed that the combined treatment (Salicylic acid (SA) at 75 ppm combined with 28-Homobrassinolide (28-BR) at 0.4 ppm) had the highest TSS to Acidity ratio than the control and every more than the use of the sole treatments in both seasons.

Table 3. Chemical characteristics of "Crimson" grape as influenced by various applied treatments during the two seasons, 2023 and 2024.

Treatments	T.S.S(%)		Acidity(%)		T.S.S/Acidity (ratio)	
	2023	2024	2023	2024	2023	2024
Control	14.36c	15.60b	0.99a	0.88a	14.51d	17.73c
SA 75 ppm	15.34b	15.71b	0.83b	0.75c	18.48b	20.95b
28-BR 0.4 ppm	14.32c	14.90b	0.84b	0.81b	17.05c	18.40c
SA 75ppm +28-BR 0.4 ppm	16.82a	21.00a	0.73c	0.63d	23.04a	33.32a
LSD at 5%	0.54	1.07	0.02	0.02	0.89	0.92

Similar letter of each column were not significantly different according to the least significant difference (LSD) at 5% levels.

Discussion

There are minimal research on the effects of a pre-veraison exogenous Salicylic acid therapy on the anthocyanin components in grapes. Clarifying the regulatory effects of exogenous SA on monoterpene and anthocyanin biosynthesis was the goal of this study. According to Yue et al. (2023), the findings will be useful as a basis for better agronomic practices utilising SA treatments. Furthermore, MeSa treatment at 0.1 mM may be the most effective method for enhancing bioactive molecules with antioxidant qualities in table grapes and quickening the on-vine ripening process, according to (García-Pastor et al., 2020). In the same line SA is a suitable and recommendable treatment for improving and expanding the phenolic and antioxidant potential of grape berries. Therefore, applying SA spray to grape berries prior to véraison may be a practical way to significantly improve their quality and nutritional content (Oraei et al., 2019). This study includes further information regarding the abilities of using 28-This study's homobrassinolide treatment indicate that BR analogues could be used as a management tool in table grape production. According to Vergara et al. (2020), their ability to enhance berry colour development when used at veraison would be highly beneficial in commercial table grape production. Exogenous treatments of several BRs analogues to "Redglobe" grape clusters have been shown by Vergara et al. (2018) to significantly improve berry colour, soluble solids content, and total anthocyanins while also changing the distribution of anthocyanin groups.

Salicylic acid's advantages involve improving photosynthetic and enzymatic activity and preserving the balance between reactive oxygen species production and degradation (Batista et al., 2019; Hu et al., 2023). Brassinosteroids have been shown to influence and promote photosynthetic activity in tomato seedlings under water stress (Shu et al., 2016; Talaat and Shawky, 2016). By positively regulating the synthesis and activation of a range of photosynthetic enzymes, including Rubisco in cucumbers, BRs stimulate photosynthesis and growth (Xia et al., 2009). (Yu et al., 2004) showed that EBR functions successfully to enhance photosynthesis, especially the Calvin cycle's ability to assimilate CO2. This was mostly due to an increase in Rubisco's initial activity.

Conclusion

The present investigation clearly reflects the ability of twice exogenous application of Salicylic acid (SA) at 75 ppm combined with 28-Homobrassinolide (28-BR) at 0.4 ppm to improve fruit Quality and Photosynthesis of Table Grapes (Vitis vinifera L.) cv. Crimson Seedless.

Acknowledgments

None

Authors' Contributions

Author declare that they has contributed equally to the article.

Conflicts of Interest

The author declare that there is no conflict of interest.

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