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Effect of Girdling and Foliar Spraying of Potassium and Cobalamin on Growth, Yield and Fruit Quality of Crimson Seedless Grapevines

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Abstract: The current investigation was carried out for two consecutive seasons (2021 and 2022) in a private vineyard located at Matay center, Minia governorate, Egypt to improve the vegetative growth aspects, vine nutritional status, yield and fruit quality attributes of Crimson Seedless by girdling and foliar spraying of potassium and cobalamin. The chosen vines were nine-year old, grown in sandy soil, irrigated under drip irrigation system, spaced at 2X3 meters apart and trellised by Gable system. The vines were cane-pruned during the last week of January with maintain a load of 72 buds/vine (6 canes X 12 buds). Eight treatments were performed as follows; trunk girdling, foliar spraying of potassium at 1% and foliar spraying of cobalamin at 300ppm were applied either solely or in combination among them, in addition to the control treatment (untreated vines). Girdling was applied after fruit set stage when the berry diameter reaches 2-3 mm, while both potassium and cobalamin were foliar sprayed three times; the 1st date (after bud burst stage), the 2nd date (at fruit set stage) and the 3rd date (at veraison stage)**.** The results displayed that girdling, potassium and cobalamin either alone or in combination among them had a positive influence on all attributes in comparison to control during the two growing seasons. The combined treatment of girdling and foliar spraying of potassium at 1% and cobalamin at 300ppm achieved the best results in terms of improving the vegetative growth aspects and vine nutritional status, which include leaf content of total chlorophyll and cane content of total carbohydrates as well as increasing yield and enhancing cluster quality attributes for Crimson Seedless grapevines.

Key words: Grape · Crimson Seedless · Girdling · Potassium · Cobalamin

INTRODUCTION

Crimson Seedless (*Vitis vinifera* L.) is late season grape cultivar, red color, crisp and attractive. Some of the major issues Egypt has with the cultivation of this cultivar are related to its low of production and lack of adequate color concentration and pigmentation of heterogeneous berries in clusters [1].

Girdling or ringing has been used commercially to stimulate the accumulation of carbohydrates in the parts above the wounds which reflects positively on the growth, yield, and berry weight as well as enhance the anthocyanin level in the berry skin and total soluble solids and therefore hasten maturity [2-8].

Potassium is a crucial nutrient for plant growth and development and plays a vital component in many of vital plant processes [9]. Potassium is essential for many plant functions such as activating enzymes responsible for metabolism of carbohydrates, nucleic acids, protein, vitamins, photosynthesis and respiration as well as controlling the opening and closing of stomata and transfer of assimilates [10]. Numerous studies showed the influence role of potassium in enhancing the yield and fruit quality characteristics [11-15].

Cobalamin, also known as vitamin B12, is a water-soluble vitamin available in the cytosol, plastids, and mitochondria of plant cells [16]. Due to the presence of cobalamin-independent methionine synthase, higher plants don't produce or need vitamin B12 [17]. The metabolism of protein, soluble lipids, carbohydrates, and ethylene can all be induced by cobalamin in plant tissue [18]. Recently, the application of cobalamin enhancing productivity and quality attributes for many fruits [18-22].

The main goal of this research is to enhance the vegetative growth traits, yield and fruit quality attributes of Crimson Seedless grape cultivar by girdling and foliar spraying of potassium and cobalamin.

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MATERIALS AND METHODS

The current investigation was conducted during 2021 and 2022 seasons in a private vineyard located at Matay center, Minia governorate to study the effect of girdling and foliar spraying of potassium and cobalamin on the yield and fruit quality of Crimson Seedless grapevines. The selected vines were nine-year old, grown in sandy soil (Table, 1), irrigated by drip irrigation system, planted at distance of 2 x 3 meters and trellised using the Gable system. The vines were cane pruned during the last week of January with maintain a load of bud load of 72 buds per vine (6 canes X 12 buds).

Ninety-six uniform vines were selected on the basis their growth depending on weight of pruning's as indirect measure for vine vigour. The replicate consisted of four vines, and each of the three replicates represents one of the conducted treatments.

Eight treatments were conducted as follows:

T1: Control (untreated vines).
T2: Girdling (G).
T3: Potassium (K) at 1%.
T4: Cobalamin (Co) at 300 ppm.
T5: G + K.
T6: G + Co.
T7: K + Co.
T8: G + K + Co.

Girdling with a doubled knife was done by removing 3-4 mm wide ring of the bark entirely around the trunk.

Potassium was used as SoluPotasse®. This product is providing a highly soluble form of potassium and sulfur, in the sulfate form. It contains 51.5% potash (K_2O w/w) and 18.7% sulfur (S w/w).

Cobalamin is a water-soluble vitamin in the methylcobalamin form. It contains 5.000mcg vitamin B12 and 800mcg folic acid.

Table 1: Physical and chemical analysis of the vineyard soil

Characters	Values
Sand (%)	78.2
Silt (%)	11.5
Clay (%)	10.3
Texture	Sandy
Organic carbon (%)	0.87
PH (1:25)	7.81
EC (Mmhos/cm)	1.03
Ca Co_3 (%)	1.37
Total N (%)	0.21
P (%)	0.14
K (%)	0.33

Girdling was applied after fruit set stage when the berry diameter reaches 2-3 mm, while both potassium at 1% and cobalamin at 300ppm were foliar sprayed three times; the 1st date (after bud burst stage), the 2nd date (at fruit set stage) and the 3rd date (at veraison stage). Triton B was used as a wetting ingredient in all foliar solutions at a rate of 0.1%, and spraying continued until runoff.

The Following Characteristics Have Been Evaluated:

Morphological Characteristics of Vegetative Growth: Two month after fruit set, the morphological studies were conducted on five non-fruiting shoots as follows: average shoots diameter (cm), average shoots length (cm) and average number of leaves/shoot as well as average leaf area (cm^2) which were taken from the sixth and seventh leaves of the tip of the growing shoot and measured according to Montero *et al.* [23].

Chemical Characteristics of Vegetative Growth:

- **Leaf Content of Total Chlorophy ll:** During full bloom, samples were collected from of leaves opposite cluster. Leaf total chlorophyll content (mg/g F.W.) was determined according to Mackinny [24].
- **Cane Content of Total Carbohydrates:** During winter pruning, cane total carbohydrates content (%) was determined as described by Hodge and Hofreiter [25].

Yield and Physical Properties of Clusters: Representative random samples consisting of six clusters/vine harvested at maturity when total soluble solids reached roughly 16-17% according to Tourky *et al*. [26], the following measurements were estimated: yield/vine (Kg) was calculation by multiplied average cluster weight by number of clusters/vine as well as average cluster weight (g) and dimensions (cm).

Physical and Chemical Properties of Berries: Fifty berries were randomly collected for each treatment, the following measurements were estimated: average berry weight (g) and size (cm^3) as well as total soluble solids (TSS) was determined as percentage by using a hand refractometer, total acidity as (g tartaric acid/100 ml juice) was determined according to A.O.A.C. [27], total sugars (%) were determined according to Sadasivam and Manickam [28] and total anthocyanin (mg/100 g fresh weight) was determined according to Yildiz and Dikmen [29].

Experimental Design and Statistical Analysis: The experiment arranged in a complete randomizes blocks

design. The statistical analysis of the data was performed according to Snedecor and Cochran [30]. Averages were compared by using the new LSD values at 5% level [31].

RESULTS AND DISCUSSION

Morphological Characteristics of Vegetative Growth: The data provided in Table 2 demonstrate that girdling, potassium and cobalamin either alone or in combination among them positively affected on shoot diameter, shoot length, number of leaves per shoot and leaf area in comparison to control during the two growing seasons.

Girdling significantly enhanced all these traits followed by in descending order potassium then cobalamin. The combined treatment of girdling and foliar spraying of potassium at 1% and cobalamin at 300 ppm markedly achieved the best vegetative growth aspects as compared to all conducted treatments in both seasons.

The positive effect of girdling could be due to its role in increasing in carbohydrate accumulation, which it reflected in the improvement of vegetative growth [2]. The results obtained are consistent with those of Fawzi *et al.* [6] on Thompson Seedless grape, who reported that girdling significantly increased the shoot length and leaf area as compared to control. Concerning the effect of potassium, Hussein and Abd El-All [12] on Flame Seedless grape cultivar and El-Badawy [13] on Crimson Seedless grape cultivar, found that foliar spraying of potassium increased leaf area. Regarding the effect of cobalamin, Al-Khawaga [19] on Superior Seedless grapes and Abd El-Bary [21] on Le-Conte pear cultivar, mentioned that the application of cobalamin increased the shoot length, diameter and leaf area as compared to control.

Chemical Characteristics of Vegetative Growth: As stated by Table 3, it is apparent that leaf total chlorophyll content as well as cane total carbohydrates content were markedly raised with all girdling, potassium and cobalamin either alone or in combination with each other in comparison to control during the two growing seasons.

Girdling significantly increased all these estimations followed by in descending order potassium then cobalamin. In comparison to all other treatments carried out in both seasons, the most optimal vine nutritional status was attained by using the combined treatment of girdling and foliar spraying of potassium at 1% and cobalamin at 300ppm.

The positive effect of girdling could be due to its role in preventing the transport of sugars to the roots; this leads to the accumulation of large amounts of carbohydrates produced by photosynthesis in the vegetative organs above the girdle [5]. These results are in agreement with those reported by Abd El-Wahab [2] on Black Monukka grape and Fawzi *et al.* [6] on Thompson Seedless grape, showed that girdling significantly increased leaf content of total chlorophyll and cane content of total carbohydrates as compared to control. Concerning the effect of potassium, Hamza and Sefan [14] found that foliar spraying of potassium increased cane content of total carbohydrates of Roumi Red grape cultivar. Regarding the effect of cobalamin, Al-Khawaga [19] on Superior Seedless grape and Abd El-Bary [21] on Le-Conte pear cultivar, mentioned that the application of cobalamin increased leaf content of total chlorophyll as compared to control.

Yield and Physical Properties of Cluster: The data provided in Table 4 indicate that girdling, potassium and cobalamin either alone or in combination among them positively affected on the yield and physical properties of cluster, which include cluster weight and dimensions in comparison to control in both seasons.

Table 2: Effect of girdling, potassium and cobalamin on morphological characteristics of vegetative growth of Crimson Seedless grapevines during 2021 and 2022 seasons

	Shoot diameter (cm)		Shoot length (cm)		Number of leaves/shoot		Leaf area (cm^2)	
Treatments	2021	2022	2021	2022	2021	2022	2021	2022
Control	0.91	0.95	141.3	147.6	21.4	21.1	163.7	169.6
Girdling (G)	1.12	1.13	153.9	157.4	23.8	23.6	171.9	175.7
Potassium (K)	1.10	1.12	149.7	156.1	23.5	22.9	166.8	172.4
Cobalamin (Co)	1.05	1.08	146.2	154.5	22.3	22.2	166.4	171.2
G + K	1.26	1.28	163.3	170.5	25.2	24.7	182.3	185.1
G + Co	1.22	1.23	159.8	164.7	24.8	24.3	179.2	184.3
K + Co	1.19	1.20	155.7	162.1	24.3	24.1	174.7	178.2
G + K + Co	1.33	1.36	169.1	175.7	25.9	25.8	183.7	186.5
New LSD at 0.05	0.04	0.07	4.7	5.1	0.6	0.9	1.1	1.3

Table 3: Effect of girdling, potassium and cobalamin on leaf total chlorophyll content and cane total carbohydrates content of Crimson Seedless grapevines during 2021 and 2022 seasons

	Total chlorophyll (mg/g F.W)		Total carbohydratesc (%)	
Treatments	2021	2022	2021	2022
Control	13.32	15.47	22.3	23.5
Girdling (G)	15.98	17.39	26.9	28.2
Potassium (K)	15.56	17.08	26.4	27.3
Cobalamin (Co)	15.05	16.36	24.1	25.7
G + K	17.01	18.29	30.8	32.9
G + Co	16.67	18.05	29.7	31.4
K + Co	15.99	17.48	28.1	29.7
G + K + Co	17.27	18.52	32.1	33.8
New LSD at 0.05	0.19	0.23	0.4	0.7

Table 4: Effect of girdling, potassium and cobalamin on yield and physical properties of clusters of Crimson Seedless grapevines during 2021 and 2022 seasons

	Yield/vine (kg)		Cluster weight (g)		Cluster length (cm)		Cluster width (cm)	
Treatments	2021	2022	2021	2022	2021	2022	2021	2022
Control	11.23	11.59	427.2	446.3	19.83	20.71	15.28	15.49
Girdling (G)	11.61	12.38	436.1	457.4	20.08	20.94	15.55	15.80
Potassium (K)	11.56	12.16	434.6	455.2	19.97	20.89	15.46	15.68
Cobalamin (Co)	11.44	11.92	431.8	451.7	19.92	20.83	15.39	15.61
G + K	12.01	12.89	448.1	469.4	20.32	21.25	15.92	16.06
G + Co	11.90	12.73	443.9	464.7	20.23	21.13	15.80	15.95
K + Co	11.73	12.51	439.5	460.1	20.15	21.07	15.66	15.86
G + K + Co	12.24	13.02	455.2	476.8	20.38	21.32	16.01	16.18
New LSD at 0.05	0.09	0.11	6.4	6.9	0.04	0.06	0.08	0.11

Table 5: Effect of girdling, potassium and cobalamin on berry physical and chemical properties of Crimson Seedless grapes during 2021 and 2022 seasons

	Average berry weight (g)		Average berry size (cm^3)		TSS (%)		Total acidity (%)		Total sugars (%)		Total anthocyanin (mg/g F.W)	
Treatments	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022
Control	3.93	3.99	3.78	3.83	15.9	16.2	0.58	0.56	12.4	12.7	30.9	31.5
Girdling (G)	4.01	4.08	3.89	3.95	16.2	16.6	0.54	0.51	13.3	13.5	31.7	32.6
Potassium (K)	3.98	4.07	3.85	3.92	16.1	16.5	0.55	0.52	13.0	13.2	31.4	32.2
Cobalamin (Co)	3.96	4.04	3.82	3.89	16.0	16.4	0.56	0.53	12.9	13.0	31.3	32.0
G + K	4.12	4.21	4.05	4.09	16.4	16.8	0.52	0.47	14.5	14.3	32.3	33.4
G + Co	4.09	4.18	4.01	4.05	16.3	16.7	0.53	0.49	14.1	14.2	32.1	33.1
K + Co	4.05	4.13	3.94	3.98	16.3	16.6	0.54	0.50	13.9	13.9	31.8	32.9
G + K + Co	4.15	4.25	4.09	4.14	16.7	17.0	0.49	0.45	14.8	14.7	32.7	33.9
New LSD at 0.05	0.03	0.02	0.03	0.04	0.2	0.1	0.01	0.02	0.2	0.3	0.2	0.1

Girdling significantly enhanced all these characteristics followed by in descending order potassium then cobalamin. The combined treatment of girdling and foliar spraying of potassium at 1% and cobalamin at 300 ppm markedly improved the yield and its attributes as compared to all conducted treatments in both seasons.

The positive effect of girdling could be due to its role in increasing in carbohydrate accumulation and as a consequent lead to an increase in yield and its attributes [32]. The results obtained are consistent with those of Eleonora *et al.* [4] on Victoria and Italia table grape cultivars, Fawzi *et al.* [6] on Thompson Seedless grape cultivar, Xi *et al.* [7] on Jumeigui grape cultivar and Abd El-Fattah *et al.* [8] on Flame Seedless grape cultivar, who reported that girdling significantly increased yield and cluster weight. Concerning the effect of potassium, Hussein and Abd El-All [12] on Flame Seedless grape cultivar and El-Badawy [13] on Crimson Seedless grape cultivar, found that foliar spraying of potassium increased yield and its components. Regarding the effect of cobalamin, Al-Khawaga [19] on Superior Seedless grapes and Abd El-Bary [21] on Le-Conte pear cultivar, mentioned that the application of vitamin B12 increased yield and cluster weight than control.

Physical and Chemical Properties of Berries: As stated by Table 5, it is noticeable that berry physical and chemical properties, which include average berry weight and size as well as berry content of TSS, acidity, total sugars and total anthocyanin were pronouncedly improved with all girdling, potassium and cobalamin

either alone or in combination with each other in comparison to control during the two growing seasons.

Girdling significantly enhanced all determinations traits followed by in descending order potassium then cobalamin. In comparison to all other treatments carried out in both seasons, the highest berry weight and size as well as berry content of TSS, total sugars and total anthocyanin and the least acidity were gained by using the combined treatment of girdling and foliar spraying of potassium at 1% and cobalamin at 300ppm.

The positive effect of girdling could be due to its role in increasing in carbohydrate accumulation and as a consequent lead to improve berry quality and advance maturity [3]. These results are in agreement with those reported by Eleonora *et al.* [4] on Victoria and Italia table grape cultivars, Fawzi *et al.* [6] on Thompson Seedless grapes, Xi *et al.* [7] on Jumeigui grapes and Abd El-Fattah *et al.* [8] on Flame Seedless grapes, who showed that girdling improved berry quality attributes.

Concerning the effect of potassium, adequate potassium nutrition helps to increase total soluble solids and decrease total acidity may be due to its role in improving sugar transport into the berries and reducing in tartaric acid which changed to potassium tartarate [33]. Furthermore, the rise in potassium was associated with an increase in anthocyanin, which is indicative of potassium role in increasing sugar content and activating some anthocyanin-producing enzymes [11]. These results are in harmony with those reported by Hussein and Abd El-All [12] on Flame Seedless grapes and El-Badawy [13] on Crimson Seedless grapes, who found that foliar spraying of potassium increased total soluble solids and total anthocyanin as well as decreased total acidity.

Regarding the effect of cobalamin, the improvement of fruit quality can be due to the cobalamin enhances the both carbohydrate pathways of Calvin and pentose phosphate and glycolysis activation, resulting in increasing in total sugars [34]. The results obtained are consistent with those of Lo'ay [18] on persimmon fruits, Al-Khawaga [19] on Superior Seedless grapes, Wassel *et al.* [20] on pomegranate fruits, Abd El-Bary [21] on Le-Conte pear fruits and Lo'ay [22] on Crimson Seedless grapes, who stated that the application of vitamin B12 increased total soluble solids and reduced total acidity in fruits.

The relationship between leaf area and fruit quality attributes:

Data illustrated in Figures (1, 2, 3 & 4) indicate the existence of a highly positive correlation between leaf area and berry weight (r =0.9944 & 0.9853), between leaf area and TSS (r = 0.9923 & 0.9722) and between leaf area and total anthocyanin (r = 0.9915 & 0.9888), while it was noticed that the presence of a highly negative correlation between leaf area and total acidity (r = - 0.9290 & - 0.9435) in the both seasons, respectively.

The fitted regressions allowed us to determine the various relationships that maximized the measured compositional parameters through the conducted treatments. Greater leaf area was required for improving fruit quality attributes by maximizing berry weight, TSS and total anthocyanin content as well as minimizing total acidity.

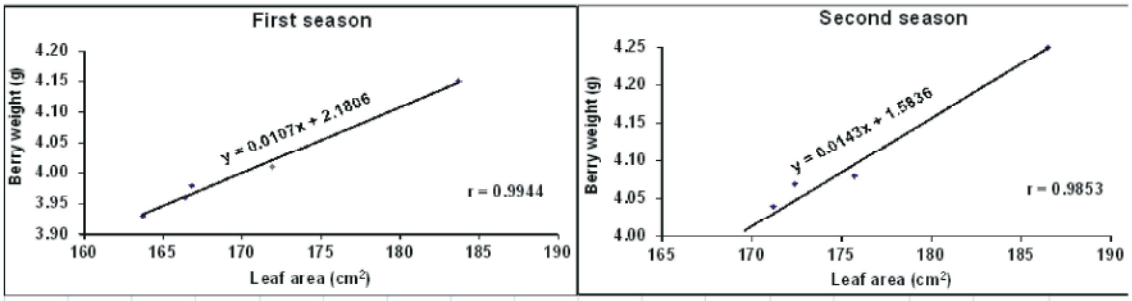

Fig (1): The relationship between leaf area (cm^2) and berry weight (g) in both seasons

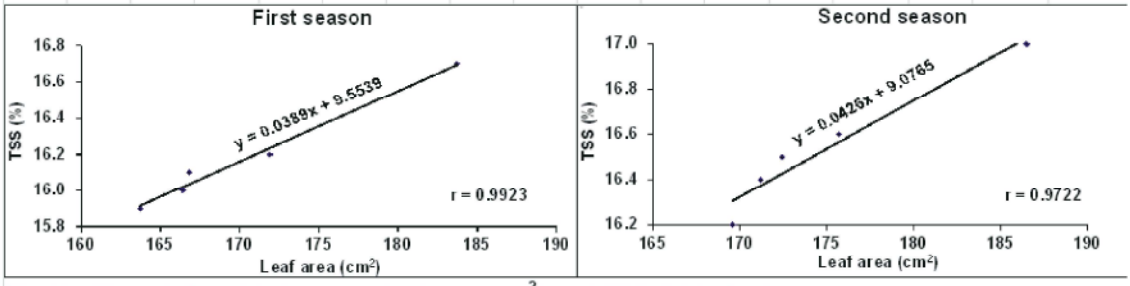

Fig (2): The relationship between leaf area (cm^2) and TSS (%) in both seasons

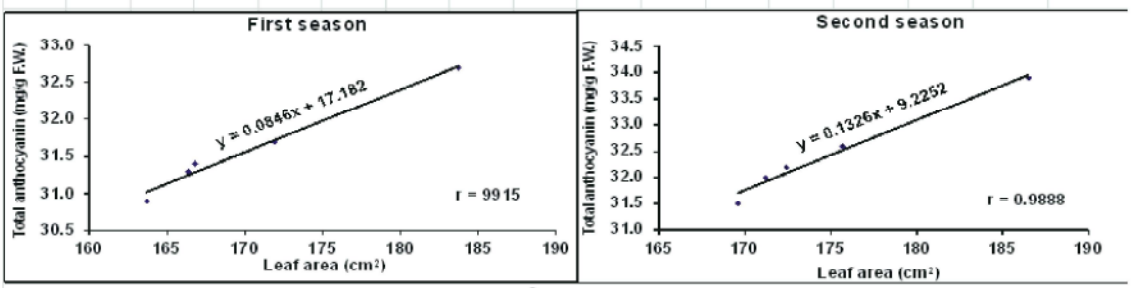

Fig (3): The relationship between leaf area (cm^2) and total anthocyanin (mg/g F.W.) in both seasons

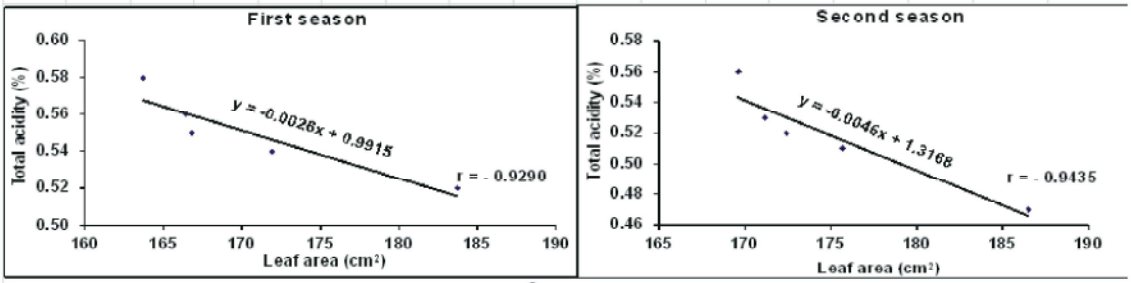

Fig (4): The relationship between leaf area (cm^2) and total acidity (%) in both seasons

CONCLUSION

From the previous results, it can be recommended to apply combined treatment of girdling and foliar spraying of potassium at 1% and cobalamin at 300ppm to give it the best results in terms of obtaining the optimum vegetative growth aspects and improving vine nutritional status which include leaf content of total chlorophyll and cane content of total carbohydrates as well as increasing yield and enhancing cluster quality attributes for Crimson Seedless grapevines.

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