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Implication of Using Potassium and Magnesium Fertilization to Improve Growth, Yield and Quality of Crimson Seedless Grapes (*Vitis vinifera* L.)

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ABSTRACT

This study was conducted during two successive seasons of 2016 and 2017 on Crimson seedless grapevines (*Vitis vinifera* L.) in a private vineyard located at El-Khatatba region, Minofia governorate, Egypt. The vines were 6 years old and spaced 2.0 m within vines and 3.0 m between rows and grown in a sandy soil under drip irrigation system. This investigation was conducted to study effect of potassium sulphate (60, 90, 120 and 150 kg/fed.) and foliar spray magnesium sulphate (0.0, 100, 200 and 300 ppm) as well as their combination in order to assure optimum growth and maximum productivity with high fruit quality.The obtained results showed that the largest leaf area and the thickest cane were resulted from the combinations of potassium at 150 kg/fed., especially those received magnesium at the high level (300 ppm) and medium level (200 ppm) in the two seasons. The highest values of berry length, width and weight were registered by the combined treatment between potassium fertilization at 150 kg/fed. and 300 ppm magnesium in the both seasons. The best cluster weight and yield/ fed. were scored by the combination of the high rate of both potassium and magnesium fertilizer in the two seasons. The combined treatment between potassium and magnesium at the high level achieved the highest values of red berries % and the lowest values of green berries % in the two seasons. Whereas, the highest record of pink and green berries % were gained by combined treatment received the lowest rate of potassium fertilizer and magnesium foliar spray at 0.0 ppm in the two seasons. The highest values of total sugars %, TSS % and anthocyanin content as well as the lowest value of acidity % were scored by the combined treatment between the high rate of potassium fertilization and magnesium foliar spray at 300 ppm in the two seasons. The highest leaf content of N, P and K % were obtained by those fertilized by the high rate of both potassium and magnesium in the two seasons. Thereby, it could be recommended that foliar application with magnesium at 300 ppm and potassium fertilization at 150 kg/fed. could be used to improve growth, yield and quality berries of Crimson seedless grapes.
Keywords: Crimson seedless grapevines, potassium, magnesium, yield and quality.

INTRODUCTION

Grape is considering one of the most important fruit crops all over the world. Botanically grape belongs to genus *Vitis*, under the family Vitaceae, which includes more than 60 genera. The cultivated area of grapes (*Vitis vinifera* L.) is spread throughout the world, with an estimated area of 7.8 million hectares in 2016, in 100 different countries. Grapes are consumed as both fresh and processed products, such as wine, jam, juice, grape seed extract, dried grapes, vinegar and grape seed oil. Global grape production in 2016 reached to 75.8 million tons of which 39% was produced in Europe, 34% in Asia, 18% in the Americas and 9% in Africa (FAO-OIV Focus, 2016).

In Egypt, grape considered the second major fruit crop after citrus. The cultivated area increased in the last few years, particularly in the newly reclaimed lands, as it reached about 196993 feddans with a total production about 1686706 tons according to the statistics of the Ministry of Agriculture, 2016.

Crimson seedless is one of the most important table grape cultivars in the world. It is a late-season red seedless table grape. The fruit ripens in mid- September and weather permitting, can be held on the vine till mid-November. The skin is medium thick and its flesh is clear, firm and crisp. It has great market acceptance due to its excellent nutritional properties and its exportable value (Rio-Segade *et al.,* 2013).

Crimson seedless is fast becoming the preferred red seedless grape in supermarkets worldwide because of its exceptional shelf life as well as it has a very distinctive, sweet, juicy flavor and elongated, pale pink berries. It has high sugar content, with half as glucose and half as fructose (Perfection, 2007). Some problems are involved with the production of Crimson seedless grapevines such as achieving the desired level of poor red color and the excessive berry set which leads to compact big clusters with small berries, which caused bunch rot (Dokoozlian and Peacock, 2001).

Potassium (K) is an essential element for all living organisms. The important roles of K in plants can be summarized into four physiological-biochemical roles: (1) activation of enzymes (Walker *et al.*, 1998); (2) cellular membrane transport processes and translocation of assimilates (Salisburg and Ross, 1992); (3) anion neutralization, which is necessary in maintenance of membrane potential (Leigh, 2001); and (4) osmotic potential regulation, which is one of the essential mechanisms in the control of plant water relations (Davies and Zhang, 1991), turgor maintenance and growth. In grape berries, potassium is the most abundant cation which contributes to charge balance and may be involved in sugar transport (Spayd *et al.,* 1993). It was found that potassium decrease acid concentrations in berries and combines with tartaric acid to produce potassium bitartrate which has limited solubility (Lang, 1983). Higher potassium supply increased T.S.S content and reduced total acidity of berries (Martin *et al.,* 2004). Adequate potassium nutrition helps to increase the contents of berries coloring and polyphenolic (Sommers, 1977). Potassium nutrition status not only affects grapevine growth and development, but also plays a vital role in plant resistance to diseases (Marschner, 1995 and Dordas, 2008). Low K supply led to poor vine growth, low yield, premature leaf fall, delaying ripening and decreased fruit K content and must pH (Conradie and Saayman, 1989 and Schreiner *et al.,* 2013).

Magnesium (Mg) is an essential macro-element for plant growth. It is a component of chlorophyll and necessary for the functional ability of ATP in many reactions. Also, it is responsible for the activation of many enzymes in photosynthesis, respiration and the formation of DNA and RNA (Salisburg and Ross, 1992). Magnesium also favorably influences assimilation (Mengel and Kirkby, 2001). Lack of Mg induces the incidence of bunch stem necrosis in grapes (Cline, 1987).

Magnesium deficiency reduces leaves chlorophylls content and changes the chlorophyll a:b ratio in favor of chlorophyll b. Visually it is seen as chlorosis of leaves, especially older ones and causes premature abscission. Chlorosis is caused either by Mg deficiency, high soil Ca content (calcareous soils) or a combination of these factors (Marschner 1995). Magnesium deficit results not only in reduced yields but also in increased risk of tendril atrophy (Furi and Hajdu, 1980 and Majer 2004). Foliar spraying with Mg fertilizers is a necessary practice to correct nutrient imbalances in grape (Gerendas and Fuhrs, 2013).

Therefore, this experiment was carried out to gain a better understanding of the needs of potassium and magnesium fertilization for optimum growth, yield and quality of Crimson seedless grape.

MATERIALS AND METHODS

This study was carried out during two successive seasons of 2016 and 2017 on Crimson seedless grapevines (*Vitis vinifera* L.) in a private vineyard located at El-Khatatba region, Minofia governorate, Egypt. The vines were six years old and spaced 2.0 m within vines and 3.0 m between rows and grown in a sandy soil under drip irrigation system (two lateral lines per row and four emitters per vine each at 4 L/ h.). During the growing season, the selected vines received standard cultural practices performed by the growers that are common among all table grape varieties. This investigation was conducted to study the effects of potassium and magnesium fertilizers in order to assure optimum growth and maximum productivity with high fruit quality.

Experiment procedures

One hundred and forty four vines of normal growth, healthy and uniform in vigour were selected to achieve this work. The vines were trellised on gabole system. Canes were pruned each season in the second week of January at 8buds/cane with 96 buds /vine .When the mean berry size reached about 8 mm in diameter, 30 clusters per vine were selected to remain in the vine and the other were removed. Physical and chemical properties of the soil of the experimental region are presented in Table (1).

Table 1. Soil characteristics of Crimson seedless at the start of the experiment.

Mechanical analysis	Value	Chemical analysis	Value	Anion and Cation (Meq/l)	Value
Coarse sand%	49.8	$CaCO_3$%	1.98	Ca^{++}	1.80
Fine sand%	35.2	Field capacity%	14.1	Na^+	1.90
Silt%	12.9	pH	7.79	Mg^+	0.82
Clay%	2.1	Organic matter%	0.31	K^+	0.21
Soil texture	sandy	EC (ds/m)	0.47	CO_3^{--}	0.0
		Total N%	0.11	HCO_3^-	2.42
				Cl^-	1.49
				SO_4^{--}	0.82

Potassium treatments

Crimson seedless vines received potassium sulfate fertilizer (48% K_2O) at the rate of 60, 90, 120 and 150kg/fed. during drip irrigation in both seasons.

Magnesium treatments

Crimson seedless vines were subjected to foliar spray with magnesium sulfate (16 %) at the rates of 0, 100, 200 and 300 ppm ten times i.e., two times before flowering and the other were done after fruit set. A surfactant (Tween 20) at a concentration of 0.01% was added to all tested solutions including the control.

Layout of the Experiment

The design of this experiment was factorial experiments in a complete randomize block design with 16 treatments represented the combinations between potassium fertilization at the rates of 60, 90, 120 and 150 kg/fed and magnesium foliar spray at the levels of 0, 100, 200 and 300 ppm (4 potassium fertilization rates x 4 magnesium levels) replicated three times (each replicate consisted of three vines).

Recorded data

Vegetative Growth

Leaf area: The average leaf area of the 5th, 6th and 7th basal leaves of three shoots from different sides of the vine during flowering stage were selected and measured using the following equation:

$$\text{Leaf area } (cm^2) = 0.587\ (L \times W).$$

Where, L = Length of leaf blade, W = Width of leaf blade (Montero *et al.,* (2000).

Cane thickness (cm): Average cane thickness (cm) was calculated in the fourth basal internodes of ten canes/ vine just before winter pruning by a vernier calliper.

Yield: At harvesting, a randomly picked 3 clusters per vine used to estimate average cluster weight (g) and then calculated average yield (ton)/ fed. (Yield = average cluster weight X number of clusters per vine (30 clusters) X number of vines per fed. (700 vines).

Berries physical characteristic

A sample of 5 clusters/ vine was taken for estimating:

1- Berry weight (g), length and width (mm).

2- Visual assessment parameters:

Skin berry colour: Red, pink and green berries divided on total berries weight and were calculated as percentages.

Berries chemical characteristic: Five clusters from each treatment were taken at random for determination of the following chemical characters of the berries: Total soluble solids (TSS %) in the juice by a Carl Zeiss hand refractometer. Total acidity (as tartaric acid g/100 ml juice) by titration against NaOH (0.1N) using phenolphthalein as an indicator according to A.O.A.C. (1995). Fruit total sugars (%) of fresh weight were determined using the Nelson arsenomolybdate colorimetric method as described by Malik and Singh (1980).

Leaf mineral content: Leaf nutrient content (NPK) were determined in the oven dried leaf samples collected (6 leaf from the base) at the flowering stage.

Total nitrogen was determined by using micro-kjeldehl method according to Pregl (1945). Phosphorus (%) was determined by using Olsen method as reported by Evenhuis and Dewaored (1980). Potassium (%) was flamephotometrically determined using the method outlined by Brown and Lilleland(1946).

Statistical analysis

All data obtained in both seasons of study were subjected to analysis of variance as factorial experiments in a complete randomize blocks design. L.S.D. method was used to differentiate between means according to Snedecor and Cochran (1980).

RESULTS AND DISCUSSION

Effect of some potassium and magnesium fertilization treatments on growth, yield, fruit quality and chemical constituents of Crimson seedless grapevines

1- Vegetative growth

Data presented in Table (2) showed that Crimson seedless grapevines received the highest rate of potassium sulfate (150 k/fed.) significantly induced the largest leaf area and the thickest cane, followed in descending order by those received potassium sulfate at 120 k/fed. in the two seasons. On contrary, the lowest values of leaf area and cane thickness were gained by those received the lowest potassium rate (60 kg / fed.), followed in ascending order by those received potassium sulfate at 90 kg / fed.in the two seasons.

In addition, the differences between the values of leaf area and cane thickness failed to reach the level of significance in the two seasons due to all application of magnesium in the two seasons. As for the interaction effect between potassium and magnesium doses, data in Table (2) revealed that all resulted combinations of potassium at the high rate statistically scored the highest values of leaf area and cane thickness, especially those received magnesium at the high level (300 ppm) and medium level (200 ppm) with non-significant differences between them in the two seasons.

The previous mentioned findings of Crimson seedless grapevines vegetative growth parameters could be interpreted on the basis of the physiological role of the nature of the used treatments action, where potassium as is consider an activator of enzymes that are essential for photosynthesis and respiration as well as enzymes that produce starch and proteins (Bhandal and Malik, 1988). The supplying of K is required for increasing vine growth, number of shoots/vine and trunk girth (Conradie and Saayman, 1989), especially when added on soil low in available K (Kasimatis and Christensen, 1976). Also, K plays an important role in plant resistance to diseases (Dordas, 2008). Also, Magnesium is a component of chlorophyll and essential for the functional ability of ATP in many reactions. It is also responsible for the activation of many enzymes in photosynthesis, respiration and the formation of DNA and RNA (Salisburg and Ross, 1992).

The obtained results of potassium and magnesium are in conformity with the findings of Mohammed *et al.,* (1993), and Amiri and Fallahi (2007) on grapes and Abd El-Kader *et al.,* (1990), Ram and Bose (2000), Kassem and El-Seginy (2002) and Mostafa *et al .,* (2007) on many fruit species.

Table 2. Effect of some potassium and magnesium fertilization treatments on leaf area and cane thickness of Crimson seedless grapevines during 2016 and 2017 seasons.

Parameter		Leaf area (cm^2)									
Season		First season					Second season				
Magnesium sulfate / Potassium sulfate		0.0	100 ppm	200 ppm	300 ppm	Mean	0.0	100 ppm	200 ppm	300 ppm	Mean
60 kg/fed.		131.6	134.2	139.2	140.2	136.3	136.2	136.9	138.2	141.2	138.1
90kg/fed.		139.4	141.4	143.6	145.0	142.4	143.1	144.0	146.2	147.1	145.1
120 kg/fed.		142.0	143.6	145.2	146.3	144.3	149.2	150.3	151.6	153.0	151.0
150kg/fed.		149.3	151.8	158.1	161.2	155.1	154.6	156.2	158.1	159.3	157.1
Mean		140.6	142.8	146.5	148.2		145.8	146.9	148.5	150.1	
L.S.D at 0.05 for	K			6.66					5.30		
	Mg			6.66					5.30		
	interaction			13.33					10.60		
Parameter		Cane thickness (cm)									
60 kg/fed.		1.06	1.06	1.09	1.11	1.08	1.12	1.14	1.15	1.15	1.14
90kg/fed.		1.19	1.21	1.23	1.24	1.22	1.21	1.23	1.22	1.25	1.23
120 kg/fed.		1.26	1.27	1.29	1.30	1.28	1.29	1.31	1.31	1.33	1.31
150kg/fed.		1.31	1.32	1.34	1.35	1.33	1.34	1.34	1.36	1.35	1.35
Mean		1.21	1.22	1.24	1.25		1.24	1.26	1.26	1.27	
L.S.D at 0.05 for	K			0.046					0.037		
	Mg			0.046					0.037		
	interaction			0.032					0.075		

2- Berry parameters

Data in Table (3) revealed that there was a positive relationship between the rate of potassium fertilization and the values of the length, width and weight of the berry, whereas the values of berry parameters increased by increasing the rate of potassium fertilization in the two seasons. Therefore, the longest, widest and heaviest berry were recorded by the high rate of potassium fertilization in the two seasons. Also, in this field all studied magnesium foliar spray failed to induce a remarkable increase in berry parameters in the two seasons of this study.

Respecting the interaction effect between both fertilizations, data in Table (3) showed that all resulted combinations affected the tested parameters of berry, with superior for the combination of the high rate of potassium fertilization in the two seasons. However, the highest values of berry length, width and weight were registered by the treatment of potassium fertilization at the high rate plus 300 ppm magnesium as foliar spray, followed by those received magnesium foliar spray at 200 ppm but without significant differences between them in the both seasons. In the reverse, the lowest values of berry parameters were gained by those fertilized with the lowest dose of potassium and zero of magnesium in the two seasons. The remained combinations occupied an intermediate position between the abovementioned treatments in the two seasons. Likewise, EL-Baz *et al*. (2003) found that, using potassium application at 350 g K2SO4/vine gave the highest berry weight. Omar and Abdelall (2005) found that potassium fertilization at 100 kg/fed. increased berry weight than fertilized with 50 or 150 kg/fed. Additionally, El Kady *et al.,* (2010) reported that potassium and magnesium fertilization significantly increased Crimson berry weight under leaving 40 or 60 eye/vine. While, potassium sulfate at 150 g supplemented with 60 g magnesium sulfate under bud load 40 eye/vine induced the highest berry weight as compared with the rest treatments. Also, Abd El-Razek *et al.,* (2011) showed that increasing the amount of K fertilization caused a significant increase in beery weight, size and their shape remained typically for cv. Crimson seedless grape.

Table 3. Effect of some potassium and magnesium fertilization treatments on berry length, width and weight of Crimson seedless grapevines during 2016 and 2017 seasons.

Parameter		**Berry length (mm)**									
Season		**First season**					**Second season**				
Magnesium sulfate / Potassium sulfate		**0.0**	**100 ppm**	**200 ppm**	**300 ppm**	**Mean**	**0.0**	**100 ppm**	**200 ppm**	**300 ppm**	**Mean**
60 kg/fed.		21.6	21.6	21.9	21.8	21.7	22.3	22.6	22.5	22.9	22.6
90kg/fed.		25.4	25.6	25.8	25.9	25.7	27.1	27.4	27.6	27.9	27.5
120 kg/fed.		28.1	28.2	28.4	28.5	28.3	27.9	28.2	28.5	28.5	28.3
150kg/fed.		29.3	29.6	29.8	29.9	29.7	29.8	29.9	30.1	30.3	30.0
Mean		26.1	26.3	26.5	26.5		26.8	27.0	27.2	27.4	
L.S.D at 0.05 for	K		1.13					0.812			
	Mg		1.13					0.812			
	interaction		2.26					1.62			
Parameter		Berry width (mm)									
60 kg/fed.		17.1	17.3	17.2	17.4	17.3	17.4	17.6	17.9	17.9	17.7
90kg/fed.		17.9	18.1	18.3	18.4	18.2	18.1	18.4	18.3	18.5	18.3
120 kg/fed.		19.3	19.5	19.7	19.9	19.6	19.5	19.6	19.5	19.8	19.6
150kg/fed.		21.4	21.6	21.9	22.3	21.8	21.1	21.4	21.6	21.8	21.5
Mean		18.9	19.1	19.3	19.5		19.0	19.3	19.3	19.5	
L.S.D at 0.05 for	K		0.896					1.05			
	Mg		0.896					1.05			
	interaction		0.621					2.11			
Parameter		Berry weight (g)									
60 kg/fed.		3.64	3.69	3.72	3.74	3.70	3.54	3.58	3.64	3.66	3.61
90kg/fed.		3.92	4.01	4.06	4.09	4.02	3.91	3.94	3.98	4.02	3.96
120 kg/fed.		4.26	4.28	4.31	4.36	4.30	4.18	4.21	4.28	4.32	4.25
150kg/fed.		4.52	4.56	4.61	4.69	4.60	4.36	4.39	4.46	4.49	4.43
Mean		4.09	4.16	4.18	4.22		4.00	4.03	4.09	4.12	
L.S.D at 0.05 for	K		0.144					0.124			
	Mg		0.144					0.124			
	interaction		0.289					0.247			

3- Yield parameters

Yield in Crimson seedless grapevines is a function of cluster weight and cluster number of vines/ fed. Hence, any nutrient management study should aim at producing maximum cluster weight, so that, the productivity could be improved reasonably. In the present work, application of potassium fertilizers exerted positive influence on yield and its attributes like cluster weight (Table, 4). In this concern, the highest cluster weight and yield/ fed. were obtained by the high rate of potassium fertilizer in the two seasons. In addition, application of 300 ppm magnesium on vine gave the most effective one for producing the greatest cluster weight and yield/ fed. in the two seasons.

Referring the interaction effect between potassium and magnesium, data in Table (4) cleared that the highest cluster weight and yield/ fed. were scored by the combination of the high concentration of both potassium and magnesium fertilizer, in the two seasons.

Furthermore, it is interesting to note that the combined treatment between potassium at the high rate and magnesium foliar spray at the medium level had also produced significantly of cluster weight and yield/ fed. in the two seasons. In the contrast, the lowest values of cluster weight and yield/ fed. were registered by the combination of the low rate of potassium fertilizer, especially those received zero magnesium foliar spray in the two seasons. The rest combinations of potassium fertilizer and magnesium foliar spray came in between the aforesaid treatments in both seasons.

The results of potassium fertilization on yield parameters of Crimson seedless grapevines were in agreement with previous studies of Mpelasoka *et al.* (2003), Krempa *et al.,* (2009), Abd El-Razek *et al.,* (2011) and Zlamalova *et al.,* (2015) on several grapevines varieties.The aforementioned results of magnesium are in conformity with those reported by Majer (2004), Krempa *et al.,* (2009), Zatloukalova *et al.,* (2011), Zlamalova *et al.,* (2015) on grapevines. In this respect, Samra *et al.,* (2007) found that yield per vine (kg) and per fed. (ton) were increased by increasing the amount of potassium fertilization. Whereas, potassium at 150 g/vine treatment gave the highest yield per vine and per fed. of Thompson seedless grapevines. Also, Rizk-Alla *et al*., (2006) mentioned that 0.3 % Mg foliar spray gave the highest values of number of clusters/ vine and yield/vine. Furthermore, El Kady *et al.,* (2010) on Flame seedless grape examined the effect of potassium sulphate at 150 and 300 g/vine and magnesium sulfate at 30 and 60 g/vine under bud load of 40 and 60 eye/vine on the productivity. They mentioned that potassium supplemented with magnesium fertilization under 40 or 60 eye/vine increased the number of clusters/vine and yield/vine. The highest yield/vine was gained by the fertilizer treatment of

300 g/vine potassium+60 g/vine magnesium sulfate under leaving 60 eye/vine. Whereas, the highest cluster weight was gained by potassium fertilization at 300 g joined with 30 g magnesium sulfate per vine under leaving 40 eyes/vine.

Table 4. Effect of some potassium and magnesium fertilization treatments on cluster weight and yield / fed. of Crimson seedless grapevines during 2016 and 2017 seasons.

Parameter		**Cluster weight (g)**									
Season		**First season**					**Second season**				
Magnesium sulfate **Potassium sulfate**		**0.0**	**100 ppm**	**200 ppm**	**300 ppm**	**Mean**	**0.0**	**100 ppm**	**200 ppm**	**300 ppm**	**Mean**
60 kg/fed.		502	511	519	524	514	484	489	497	504	494
90kg/fed.		539	548	561	568	554	526	531	539	542	535
120 kg/fed.		552	564	572	579	567	542	549	558	564	553
150kg/fed.		594	604	614	626	610	586	598	604	616	601
Mean		547	557	567	574		535	542	550	557	
L.S.D at 0.05 for	K			19.48					17.94		
	Mg			19.48					17.94		
	interaction			38.96					35.88		
Parameter		Yield/fed. (ton)									
60 kg/fed.		10.54	10.73	10.90	11.00	10.79	10.16	10.27	10.44	10.58	10.36
90kg/fed.		11.32	11.52	11.78	11.93	11.64	11.05	11.15	11.32	11.38	11.23
120 kg/fed.		11.59	11.84	12.01	12.16	11.90	11.38	11.53	11.72	11.84	11.62
150kg/fed.		12.47	12.68	12.89	13.15	12.80	13.31	12.56	12.63	12.94	12.86
Mean		11.48	11.69	11.89	12.06		11.48	11.38	11.53	11.68	
L.S.D at 0.05 for	K			0.334					0.396		
	Mg			0.334					0.396		
	interaction			0.667					0.791		

4- Fruit physical properties

Data in Tables (5) showed that all studied potassium and magnesium treatments affected fruit physical properties of Crimson seedless berries i.e. red, pink and green berries percentages in the two seasons of study. In this respect, potassium fertilizer at the high rate showed to be the most effective one for inducing the highest values of red berries % and the lowest values of green berries % in the two seasons.

In the same pattern, magnesium foliar spray at the high level recorded the highest values of red berries % and the lowest values of green berries % in the two seasons. In general, the combined treatment between potassium at the high rate and magnesium at the high level scored the highest values of red berries % and lowest values of green berries % in the two seasons. Whereas, the highest records of pink and green berries percentages were gained by those received the lowest rate of potassium fertilizer and received 0.0 ppm magnesium foliar spray in the two seasons.

Table 5. Effect of some potassium and magnesium fertilization treatments on red, pink and green berries % of Crimson seedless grapevines during 2016 and 2017 seasons.

Parameter		**Red berries %**									
Season		**First season**					**Second season**				
Magnesium sulfate **Potassium sulfate**		**0.0**	**100 ppm**	**200 ppm**	**300 ppm**	**Mean**	**0.0**	**100 ppm**	**200 ppm**	**300 ppm**	**Mean**
60 kg/fed.		56.6	57.9	59.3	62.7	59.1	58.9	60.1	61.9	63.1	61.0
90kg/fed.		61.2	63.2	66.4	70.2	65.3	64.9	69.2	74.5	76.1	71.2
120 kg/fed.		68.9	71.4	74.2	76.0	72.6	69.2	71.6	76.1	78.2	73.8
150kg/fed.		71.6	73.6	75.8	78.7	74.9	75.5	78.2	79.4	81.5	78.7
Mean		64.6	66.5	68.9	71.9		67.1	69.8	73.0	74.77	
L.S.D at 0.05 for	K			2.218					2.441		
	Mg			2.218					2.441		
	interaction			4.435					4.882		
Parameter		Pink berries %									
60 kg/fed.		35.3	34.60	34.20	31.50	33.9	32.9	31.7	32.9	32.2	32.4
90kg/fed.		31.0	30.20	28.10	25.40	28.7	28.5	25.0	22.1	20.8	24.1
120 kg/fed.		25.2	23.60	22.10	22.10	23.3	27.4	25.7	22.1	20.1	23.8
150kg/fed.		26.7	25.10	23.90	21.00	24.2	23.2	21.1	20.3	18.2	20.7
Mean		29.6	28.4	27.1	25.0		28.0	25.9	24.4	22.8	
L.S.D at 0.05 for	K			2.76					2.92		
	Mg			2.76					2.92		
	interaction			5.52					5.84		
Parameter		Green berries %									
60 kg/fed.		8.1	7.5	6.5	5.8	7.0	8.2	8.2	5.2	4.7	6.6
90kg/fed.		7.8	6.6	5.5	4.4	6.1	6.6	5.8	3.4	3.1	4.7
120 kg/fed.		5.9	5.0	3.7	1.9	4.1	3.4	2.7	1.8	1.7	2.4
150kg/fed.		1.7	1.3	0.3	0.3	0.9	1.3	0.7	0.3	0.3	0.7
Mean		5.9	5.1	4.0	3.1		4.9	4.4	2.7	2.5	
L.S.D at 0.05 for	K			0.89					1.01		
	Mg			0.89					1.01		
	interaction			1.79					1.02		

5- Fruit chemical properties

Data in Tables (6&7) indicated that total sugars %, TSS %, total acidity % and anthocyanin (mg/ 100 g F.W) were greatly influenced by all tested treatments of potassium fertilizers and magnesium spray in the two seasons. In this regard, it worthy to note that there were a positive correlation between the values of total sugars %, TSS % and anthocyanin (mg/100 g F.W) and the rates of potassium and magnesium, so as the rates of potassium and magnesium increased the values of total sugars %, TSS % and anthocyanin contents increased until reach to the maximum increasing at the highest rate in the two seasons. Therefore, the highest values of total sugars %, TSS % and anthocyanin content as well as the lowest value of acidity % were scored by the combined treatment between the high rate of potassium fertilization and magnesium foliar spray at 300 ppm in the two seasons.

Table 6. Effect of some potassium and magnesium fertilization treatments on fruit total sugars and T.S.S percentages of Crimson seedless grapevines during 2016 and 2017 seasons.

Parameter					**Total sugars %**					
Season			**First season**					**Second season**		
Magnesium sulfate / Potassium sulfate	**0.0**	**100 ppm**	**200 ppm**	**300 ppm**	**Mean**	**0.0**	**100 ppm**	**200 ppm**	**300 ppm**	**Mean**
60 kg/fed.	16.09	16.13	16.34	16.38	16.24	16.24	16.36	16.41	16.50	16.38
90kg/fed.	16.81	16.91	16.99	17.06	16.94	17.06	17.12	17.22	17.44	17.21
120 kg/fed.	17.23	17.36	17.50	17.61	17.42	17.57	17.77	17.86	18.00	17.80
150kg/fed.	17.64	17.57	17.87	18.02	17.77	17.77	18.06	18.14	18.23	18.05
Mean	16.94	16.99	17.18	17.27		17.16	17.33	17.41	17.54	
L.S.D at 0.05 for K		0.204						0.245		
Mg		0.204						0.245		
interaction		0.409						0.489		
Parameter					T.S.S %					
60 kg/fed.	16.88	16.94	17.06	17.16	17.01	17.07	17.11	17.16	17.21	17.14
90kg/fed.	17.46	17.69	17.72	17.81	17.67	17.61	17.75	17.98	18.16	17.88
120 kg/fed.	17.96	18.06	18.27	18.37	18.17	18.26	18.38	18.56	18.74	18.47
150kg/fed.	18.38	18.49	18.67	18.71	18.56	18.37	18.67	18.82	19.04	18.73
Mean	17.67	17.80	17.93	18.01		17.83	17.98	18.13	18.29	
L.S.D at 0.05 for K		0.339						0.163		
Mg		0.339						0.163		
interaction		0.677						0.325		

Table 7. Effect of some potassium and magnesium fertilization treatments on fruit acidity percentages and anthocyanin of Crimson seedless grapevines during 2016 and 2017 seasons.

Parameter					**Acidity %**					
Season			**First season**					**Second season**		
Magnesium sulphate / Potassium sulphate	**0.0**	**100 ppm**	**200 ppm**	**300 ppm**	**Mean**	**0.0**	**100 ppm**	**200 ppm**	**300 ppm**	**Mean**
60 kg/fed.	0.63	0.59	0.56	0.51	0.5725	0.66	0.64	0.61	0.58	0.62
90kg/fed.	0.59	0.56	0.54	0.50	0.5475	0.60	0.57	0.57	0.55	0.57
120 kg/fed.	0.52	0.49	0.46	0.46	0.4825	0.53	0.52	0.48	0.42	0.49
150kg/fed.	0.43	0.43	0.42	0.40	0.4200	0.46	0.44	0.44	0.42	0.44
Mean	0.54	0.52	0.50	0.47		0.56	0.54	0.53	0.49	
L.S.D at 0.05 for K			0.037					0.052		
Mg			0.037					0.052		
interaction			0.075					0.105		
Parameter					Anthocyanin (mg/100 g F.W.)					
60 kg/fed.	31.84	32.11	32.91	32.96	32.46	32.48	32.59	32.76	32.81	32.66
90kg/fed.	36.36	36.86	37.18	37.28	36.92	38.29	38.46	38.80	38.93	38.62
120 kg/fed.	39.82	41.08	41.68	41.92	41.13	43.45	43.66	43.79	43.84	43.69
150kg/fed.	41.34	41.86	41.92	42.13	41.81	45.28	45.71	45.91	45.93	45.71
Mean	37.34	37.98	38.42	38.57		39.88	40.10	40.31	40.38	
L.S.D at 0.05 for K			1.83					2.03		
Mg			1.83					2.03		
interaction			3.66					4.07		

The effect of high K fertilization on increasing total soluble solids and decreasing total acidity might be due to the improvement of sugar transport into the berries and the reduction in tartaric acid which changed to potassium tartarate (Martin, 2004).

The increment in anthocyanin was related to the increase in K-percentage in each NPK ratio which reflects the position effect of K^+ on increasing anthocyanin content which indeed due to the role of K^+ in improving sugar content and activates some enzymes responsible foranthocyanin biosynthesis (Sommmers, 1997).

The positive results of potassium supply on enhancing chemical fruit quality of Crimson seedless grapevines are in conformity with the findings of Mpelasoka *et al.,* (2003), Martin *et al.,* (2004), Krempa *et al.,* (2009), Abd El-Razek *et al.,* (2011) and Zlamalova *et al.,* (2015) on several grapevine cvs.

The results of magnesium are in agreement with those reported by Krempa *et al.,* (2009), Majer (2004), Zatloukalova *et al.,* (2011), Gerendas and Fuhrs (2013) and Zlamalova *et al.,* (2015) on grapevines. El Kady *et al.,* (2010) mentioned that the fertilizer treatment of 300 g/vine potassium+60 g/vine magnesium sulphate under leaving 60 eye/vine gave higher TSS % and lower total acidity % in berry juice than the other treatments or the control. On the other hand, Ruhl *et al.,* (1992) and Trolove *et al.,* (2008) found that Mg foliar spraying had no effect on in several grape juice quality parameters.

Regarding berry anthocyanin content, Abdel-Mohsen (2003) reported that potassium fertilization increased anthocyanin pigment in berry skin. In addition, El Kady *et al.,* (2010) reported that potassium and magnesium fertilization significantly increased anthocyanin content. Hence, the fertilizer treatment of 300 g/vine potassium+60 g/vine magnesium sulphate gave higher value of anthocyanin.

5- Leaf mineral content in leaves

Data in Table (8) reported that leaf N, P and K percentages increased with increasing the rate of potassium fertilization in the two seasons. So, the high rate of potassium gave the highest values of leaf N, P and K percentages in the two seasons. While, magnesium treatments failed to induce significant differences in these parameters in most cases in the two seasons. However, the highest values of N, P and K percentages were obtained by those fertilized by the high rate of potassium and sprayed with magnesium at 300 ppm in the two seasons.

The aforementioned results of potassium and magnesium fertilization on leaf mineral constituents are in accordance with those reported by Trolove *et al.,* (2008), Gluhic *et al.,* (2009) on grapevines and Sarrwy *et al.,* (2012) on Balady mandarin.

Consequently, it is preferable from the previous results that treating Crimson seedless plants with the combined treatment between potassium sulphate at 150 kg/fed. and 300 ppm magnesium sulphate foliar spray for enhancing growth and productivity of this plant. Therefore, the present study strongly admit the use of such treatment to provide good and high quality characteristics.

Table 8. Effect of some potassium and magnesium fertilization treatments on leaf N, P and K content of Crimson seedless grapevines during 2016 and 2017 seasons.

Parameter		**Leaf N %**									
Season		**First season**					**Second season**				
Magnesium sulfate / Potassium sulfate		**0.0**	**100 ppm**	**200 ppm**	**300 ppm**	**Mean**	**0.0**	**100 ppm**	**200 ppm**	**300 ppm**	**Mean**
60 kg/fed.		1.57	1.62	1.73	1.71	1.66	1.48	1.56	1.52	1.57	1.53
90kg/fed.		1.76	1.83	1.81	1.86	1.82	1.59	1.63	1.66	1.69	1.64
120 kg/fed.		1.89	1.91	1.94	1.95	1.92	1.72	1.76	1.79	1.82	1.77
150kg/fed.		1.92	1.93	1.96	1.97	1.95	1.78	1.81	1.86	1.92	1.84
Mean		1.79	1.82	1.86	1.87		1.64	1.69	1.71	1.75	
L.S.D at 0.05 for	K			0.095					0.102		
	Mg			0.095					0.102		
	interaction			0.190					0.204		
Parameter		Leaf P %									
60 kg/fed.		0.159	0.163	0.169	0.168	0.165	0.161	0.168	0.167	0.172	0.167
90kg/fed.		0.183	0.189	0.196	0.195	0.191	0.179	0.189	0.193	0.195	0.189
120 kg/fed.		0.205	0.205	0.219	0.221	0.213	0.211	0.216	0.226	0.234	0.222
150kg/fed.		0.208	0.216	0.224	0.228	0.219	0.218	0.229	0.237	0.246	0.233
Mean		0.188	0.193	0.202	0.203		0.193	0.201	0.206	0.212	
L.S.D at 0.05 for	K			0.026					0.026		
	Mg			0.026					0.026		
	interaction			0.052					0.052		
Parameter		Leaf K %									
60 kg/fed.		1.34	1.39	1.41	1.43	1.39	1.41	1.48	1.52	1.51	1.48
90kg/fed.		1.46	1.51	1.59	1.62	1.55	1.56	1.61	1.68	1.72	1.64
120 kg/fed.		1.67	1.72	1.79	1.82	1.75	1.78	1.81	1.86	1.91	1.84
150kg/fed.		1.71	1.81	1.86	1.92	1.83	1.80	1.89	1.94	1.97	1.90
Mean		1.55	1.61	1.66	1.70		1.64	1.70	1.75	1.78	
L.S.D at 0.05 for	K			0.111					0.174		
	Mg			0.111					0.174		
	interaction			0.223					0.349		

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تداعيات إستخدام التسميد بالبوتاسوم والماغنسيوم لتحسين نمو ومحصول وجودة العنب كريمسون

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أجريت هذه التجربة خلال موسمى ٢٠١٦ و٢٠١٧ على كروم العنب صنف كريمسون بمزرعة خاصة بمنطقة الخطاطبة – محافظة المنوفية – مصر. وكانت الكروم المستخدمة عمر ٦ سنوات ومنزرعة على مسافات ٢×٣م فى تربة رملية تحت ظروف الرى بالتنقيط. وقد أجريت هذه التجربة لدراسة تأثير التسميد بسلفات البوتاسيوم (٦٠، ٩٠، ١٢٠، ١٥٠ كجم/ فدان) والرش بسلفات الماغنسيوم (صفر، ١٠٠، ٢٠٠، ٣٠٠ جزء فى المليون) وتفاعلاتهم وذلك للحصول على أفضل نمو وأعلى إنتاجية وجودة للعنب صنف كريمسون. وقد أوضحت النتائج المتحصل عليها أن أكبر مساحة ورقية وسمك القصبة قد تم الحصول عليهما عند إستخدام التسميد بالبوتاسيوم بالمعدل المرتفع (١٥٠كجم/ الفدان) مع الرش بسلفات الماغنسيوم خاصة التركيز المرتفع (٣٠٠ جزء فى المليون) والمتوسط (٢٠٠ جزء فى المليون) فى كلا الموسمين. تم الحصول على أكبر طول وعرض ووزن للحبة عند إستخدام المعاملة المختلطة بين التسميد بالبوتاسيوم بالمعدل المرتفع والرش بالماغنسيوم بتركيز ٣٠٠ جزء فى المليون فى كلا الموسمين. أيضا كان أكبر وزن للعنقود وأعلى محصول ثمار/ فدان تم الحصول عليه عند إستخدام تفاعلات المعدل المرتفع من التسميد البوتاسى مع الرش بسلفات الماغنسيوم خاصة التركيز المرتفع (٣٠٠ جزء فى المليون) فى كلا الموسمين. وقد أعطت المعاملة المختلطة بين الجرعة المرتفعة من البوتاسيوم والماغنسيوم أكبر نسبة للحبات الحمراء وأقل نسبة للحبات الخضراء بينما أعطت معاملة التسميد البوتاسى بالتركيز المنخفض (٦٠ كجم/ فدان) أكبر نسبة للحبات البمبى (الأحمر الفاتح) والخضراء فى كلا الموسمين. وقد نتج أكبر محتوى للحبات من السكريات الكلية والمواد الصلبة الذائبة الكلية والانثوسيانين وأقل محتوى من الحموضة عند إستخدام المعاملة المختلطة بين التسميد بالبوتاسيوم بالمعدل المرتفع مع الرش بالماغنسيوم بتركيز ٣٠٠ جزء فى المليون فى كلا الموسمين. وأدت معاملة التسميد بالبوتاسيوم بالمعدل المرتفع (١٥٠ كجم/ فدان) مع الرش بالماغنسيوم بتركيز ٣٠٠ جزء فى المليون إلى أعلى محتوى للأوراق من النيتروجين والبوتاسيوم والفوسفور فى كلا الموسمين. لذا يمكن التوصية برش كرمات العنب صنف كريمسون بتركيز ٣٠٠ جزء فى المليون من كبريتات الماغنسيوم مع التسميد بالبوتاسيوم بمعدل ١٥٠ كجم/ فدان لتحسين النمو والانتاجية وصفات الجودة للحبات.