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Attempts to Improve the Berry Quality and Storability of Grape "Crimson Seedless" with Potassium Compounds under Desert Conditions

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Abstract: This investigation was carried out for two successive seasons i.e. 2008 and 2009 on six years old Crimson Seedless grapevine. The comparative effects of foliar application of potassium at three concentrations from three sources as follows: potassium thiosulfate at 1.5, 2.5 or 3.5 cm/L; monopotassium phosphate at 1.5, 2.5 or 3.5 g /L and amiphole potassium at 1.5, 2.5 or 3.5 cm/L. Trees were sprayed at fruit setting or veraison phenological stages or both stages were assessed. The concerned parameters were the basic berry quality parameters at harvest, potassium berry content and berry quality after cold storage at 0°C for 30 days. Data clearly pointed out clear enhancements in berry quality in terms of berry weight, firmness, TSS%, acidity%, TSS/acid ratio, total sugars and total anthocyanin content where these parameters were accompanied by higher berry potassium content. Superiority was due to double sprays of potassium thiosulfate at 3.5 cm/L. The afore mentioned treatment was accompanied by highest berry potassium level indicating that, this source of potassium led to highest absorption of potassium which induced these enhancements in addition to the sulpher content of this compound which enhanced the potassium effect. High potassium content also resulted in maintaining the fruit quality at cold storage and this might be attributed to the effect of potassium in diminishing the respiration rate thus reducing the sugars consumption and thereby retarding the senescence phase.

Key words: Grapevine · Crimson seedless · Potassium thiosulfate · Monopotassium phosphate · Amiphole potassium · Fruit quality · Cold storage

INTRODUCTION

Crimson Seedless is a red, seedless, late ripening table grape. It originated in Fresno, California as a cross between C33-199 and Emperor, selected in 1983 [1]. This cultivar has been introduced Egypt in the last decade. Crimson Seedless grapes have been grown successfully in the desert lands. Yet, it has been met with some obstacles as berry size and low coloration basically due to heat stress which inhibit anthocyanin accumulation [2-4]. Ethrel has been suggested by many workers for better coloration [5, 6]. Health hazards restricted ethrel usage or reduced it drastically in many places worldwide. Potassium known as a quality element was proposed for enhancing grape berry quality in general and coloration in specific [7-11]. It was found to increase the berry content of anthocyanin leading to better coloration [5, 12, 13]. Its' effect in maintaining berry quality at cold storage was also indicated [14-19].

Potassium absorption has two peaks, the first at fruit setting stage and the second during berry maturation [12, 20, 21]. Its' effect is related to the source from which it has been taken [5, 17, 18]. This is due to better absorption and or the effect of other substances composing the source [11, 14, 22-24].

The scope of the present investigation is to detect the comparative effect of three sources of potassium at three concentrations sprayed at two phenological stages on the basic physical and chemical berry characteristics at harvest and after cold storage.

MATERIALS AND METHODS

This investigation was carried out for two successive seasons i.e. 2008 and 2009 on six years old Crimson Seedless grapevines in a private vineyard located at El- Bostan region in Behera governorate. The vines are grown in sandy soil, spaced at 1.5 x 3 m, irrigated with drip

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irrigation system. For this investigation, eighty four vines were chosen for each considered season. Vines were uniform, all head trained, cane pruned and trellised with a gable system. Each vine bore eight canes that were shorten to 12 buds with a total number of clusters adjusted to 32/vine. The normal management practices that were recommended by the Ministry of Agriculture were carried out.

The following treatments were sprayed each on three separate vines (each acting as a replicate). The randomized complete blocks design was adopted for the currant investigation. The treatments were potassium thiosulfate (KTS: $K_2S_2O_3$, 36.5% K_2O 8.8% S) at 1.5, 2.5 or 3.5 cm/liter, monopotassium phosphate (KH_2PO_4,34% K_2O, 52% P_2O_5) at 1.5, 2.5 or 3.5 g/liter and amiphole potassium (34% K_2O,total amino acid L-α 7%) at 1.5, 2.5 or 3.5 cm/liter. These treatments were sprayed at fruit set (when an average of 70% of the blossoms/cluster reached that stage), at the veraison stage when 20% of the berries/cluster were colorized) or at both stages.

Three vines were left untreated (control) for comparison When control clusters reached the maturity stage (16-17% juice Brix) as previously indicated by David *et al.*[1], the crop born on each considered vine was harvested separately. Infected and deformed clusters were discarded. The remaining clusters were placed in field boxes, transferred to the laboratory. Three representing clusters were selected from the crop of each vine for evaluating quality at harvest as follows: Average berry weight (g), berry firmness (g/cm^2), juice TSS (%) by hand refractometer, juice acidity (%) as tartaric acid according to A.O.A.C. [25], TSS/acid ratio, total sugars (%) according to Smith *et al.* [26], total anthocyanin of the berry skin (mg/100g fresh weight) according to Husia *et al.* [27] for fruits at harvest and potassium (%) in the berries was estimated at harvest using the method described by Brown and Lilleland [28].

The remaining cluster were placed in two cartoon boxes i.e. one for evaluating weight loss percentage and the other for evaluating quality after 30 days cold storage. Boxes were placed in cold storage at 0°C and 90- 95% relative humidity. The criteria used for assessment were: berry firmness (g/cm^2), shattering percentage, juice TSS (%), juice acidity (%) and TSS/acid ratio.

The attained results were tabulated and statistically analyzed according to Snedecor and Cachran [29]. The mean values were compared by using Duncan's multiple range test at 5% level [30].

RESULTS AND DISCUSSION

Effect of Treatments on Fruit Quality at Harvest: Average fruit weight was insignificantly affected by the time of spraying (Table 1). Significantly the heaviest berries were obtained due to spraying potassium thiosulfate 2.5 or 3.5 cm/L or monopotassium phosphate at 2.5 or 3.5 g/L in both seasons. Comparable results were due to spraying amifol potassium at 3.5 cm/L in the first season only. The interaction results were significant in both seasons. Data show that, using the highest concentration (3.5) resulted in significantly the heaviest berries regardless the source of potassium used and the time of application. Statistically equal if using potassium thiosulfate at 2.5 cm/L or monopotassium phosphate 2.5 g/L as potassium source regardless the time of application.

Berry firmness was significantly the least when spraying was carried out at the fruit set stage (Table 2). Whereas, it was significantly the highest when spraying was carried out twice. Untreated berries attained significantly the least firmness in both seasons. Spraying potassium thiosulfate at 3.5 cm/L induced significantly the highest berry firmness compared with control and remaining treatments. Interaction data show that, significantly the highest berry firmness was attributed to double potassium thiosulfate sprays at 3.5 cm/L.

On the average significantly the highest juice TSS% was due to the double sprays (Table 3). Comparable results were achieved due to spraying in the veraison stage in the first season only. As for the average treatment effect, spraying potassium thiosulfate at 3.5 cm/L resulted in significantly the highest juice TSS% when compared with control and the remaining treatments. Insignificant differences were attributed by the potassium thiosulfate treatment at 2.5 and 3.5 cm/L in the first season only. Interaction results showed significantly highest juice TSS% when spraying potassium thiosulfate at 3.5 cm/L regardless the time of spray. Comparable results were attained by double sprays of potassium thiosulfate at 2.5 cm/L in both seasons and at the veraison stage in the first season only.

Juice acidity was significantly the least with the double sprays on the average (Table 4). Control berries attained significantly the highest acidity. Insignificant differences were due to the amifol treatment at 1.5 cm/L in both seasons and monopotassium phosphate treatment at 1.5 g/L in the first season only. Whereas, potassium

Table 1: Effect of conducted treatments on berry weight (g) of Crimson Seedless grape at harvest during 2008 and 2009 seasons

	Berry weight (g)							
	2008 Season				2009 Season			
	Phase of spraying				Phase of spraying			
Treatments	Fruit set	Veraison	Fruit set+ Veraison	Mean	Fruit set	Veraison	Fruit set+ Veraison	Mean
Potassium thiosulfate 1.5 cm/L	3.02 e-h	3.10 d-h	3.16 c-h	3.09 C-E	3.11 e-h	3.19 d-h	3.25 c-h	3.18 DE
Potassium thiosulfate 2.5 cm/L	3.82 a-d	3.90 a-c	3.96 ab	3.89 A	3.97 a-d	4.02 a-c	4.11 ab	4.03 AB
Potassium thiosulfate 3.5 cm/L	3.86 a-c	3.95 ab	4.01 a	3.94 A	3.99 ac	4.08 ab	4.20 a	4.09 A
Monopotassium phosphate 1.5 g/L	2.83 f-h	3.01 e-h	3.07 d-h	2.97 D-F	2.94 f-h	3.11 e-h	3.11 e-h	3.05 EF
Monopotassium phosphate 2.5 g/L	3.56 a-f	3.64 a-e	3.70 a-e	3.63 AB	3.66 a-g	3.75 a-e	3.80 a-e	3.74 A-C
Monopotassium phosphate 3.5 g/L	3.80 a-d	3.89 a-c	3.95 ab	3.88 A	3.86 a-e	3.95 a-d	4.02 a-c	3.94 AB
Amiphole potassium 1.5 cm/L	2.75 gh	2.83 f-h	2.96 e-h	2.85 EF	2.87 gh	2.95 f-h	3.07 e-h	2.96 EF
Amiphole potassium 2.5 cm/L	3.24 b-h	3.32 a-h	3.38 a-h	3.31 B-D	3.32 b-h	3.41 a-h	3.48 a-h	3.40 C-F
Amiphole potassium 3.5 cm/L	3.43 a-g	3.52 a-f	3.58 a-f	3.51 A-C	3.52 a-g	3.60 a-g	3.67 a-f	3.59 B-D
Control	2.63 h	2.63 h	2.63 h	2.63 F	2.71 h	2.71 h	2.71 h	2.71 F
Mean	3.29 *A*	3.38 *A*	3.44 *A*	-	3.39 *A*	3.48 *A*	3.54 *A*	-

Mean separation by Duncan Multiple Range (0.05)

Table 2: Effect of conducted treatments on firmness (g/cm2) of Crimson Seedless grape at harvest during 2008 and 2009 seasons

	Firmness (g/cm^2)							
	2008 Season				2009 Season			
	Phase of spraying				Phase of spraying			
Treatments	Fruit set	Veraison	Fruit set+ Veraison	Mean	Fruit set	Veraison	Fruit set+ Veraison	Mean
Potassium thiosulfate 1.5 cm/L	484.5 o	490.2 n	512.3 l	495.7 G	510.3 r	518.2 q	540.5 o	523.0 G
Potassium thiosulfate 2.5 cm/L	554.6 f	560.3 e	592.7 b	569.2 B	604.4 h	612.7 g	644.8 b	620.6 B
Potassium thiosulfate 3.5 cm/L	566.8 d	572.6 c	604.8 a	581.4 A	612.5 g	623.6 e	656.7 a	630.9 A
Monopotassium phosphate 1.5 g/L	451.2 r	463.3 q	474.2 p	462.9 H	489.2 u	502.3 s	518.4 q	503.3 H
Monopotassium phosphate 2.5 g/L	517.3 k	528.4 j	560.5 e	535.4 D	575.4 c	587.5 k	619.6 f	594.2 C
Monopotassium phosphate 3.5 g/L	536.4 h	543.2 g	575.6 c	551.7 C	594.3 j	601.5 i	633.6 d	609.8 D
Amiphole potassium 1.5 cm/L	440.7 s	452.0 r	474.2 p	455.6 I	484.2 u	496.3 t	510.4 r	497.0 I
Amiphole potassium 2.5 cm/L	488.5 n	495.4 m	517.4 k	500.4 F	532.3 p	539.5 o	562.6 m	544.8 F
Amiphole potassium 3.5 cm/L	498.3 m	510.7 l	532.6 i	513.9 E	554.2 n	566.4 l	589.5 k	570.0 E
Control	435.2 t	435.2 t	435.2 t	435.2 J	462.3 w	462.3 w	462.3 w	462.3 J
Mean	497.4 *C*	505.1 *B*	528.0 *A*	-	541.9 *C*	551.0 *B*	573.8 *A*	-

Mean separation by Duncan Multiple Range (0.05)

Table 3: Effect of conducted treatments on TSS% of Crimson Seedless grape at harvest during 2008 and 2009 seasons

	Total soluble solids (%)							
	2008 Season				2009 Season			
	Phase of spraying				Phase of spraying			
Treatments	Fruit set	Veraison	Fruit set+ Veraison	Mean	Fruit set	Veraison	Fruit set+ Veraison	Mean
Potassium thiosulfate 1.5 cm/L	16.2 kl	16.4 j-l	17.0 h-k	16.53 FG	16.5 lm	16.8 j-m	17.4 h-j	16.90 E
Potassium thiosulfate 2.5 cm/L	18.2 b-f	18.5 a-d	18.7 a-c	18.47 AB	18.8 c-e	19.2 b-d	19.4 a-c	19.13 B
Potassium thiosulfate 3.5 cm/L	18.7 a-c	19.0 ab	19.2 a	18.97 A	19.5 ab	19.8 ab	20.0 a	19.77 A
Monopotassium phosphate 1.5 g/L	16.0 l	16.0 l	16.6 i-l	16.20 GH	16.2 m	16.4 lm	17.0 j-l	16.53 F
Monopotassium phosphate 2.5 g/L	17.2 g-j	17.7 d-h	18.0 c-g	17.63 CD	17.8 g-i	18.2 e-g	18.6 d-f	18.20 C
Monopotassium phosphate 3.5 g/L	17.7 d-h	18.2 b-f	18.4 a-e	18.10 BC	18.0 f-h	18.5 ef	18.8 c-e	18.43 C
Amiphole potassium 1.5 cm/L	16.0 l	16.0 l	16.2 kl	16.07 GH	16.4 lm	16.6 k-m	17.0 j-l	16.67 EF
Amiphole potassium 2.5 cm/L	16.4 j-l	16.7 i-l	17.2 g-j	16.77 EF	16.9 j-l	17.2 i-k	17.7 g-l	17.27 D
Amiphole potassium 3.5 cm/L	16.7 i-l	17.4 f-i	17.5 e-i	17.20 DE	17.0 j-l	17.4 h-j	17.8 g-i	17.40 D
Control	16.0 l	16.0 l	16.0 l	16.00 H	16.4 lm	16.4 lm	16.4 lm	16.40 F
Mean	16.91 *B*	17.19 *AB*	17.48 *A*	-	17.35 *C*	17.65 *B*	18.01 *A*	-

Mean separation by Duncan Multiple Range (0.05)

Table 4: Effect of conducted treatments on acidity % of Crimson Seedless grape at harvest during 2008 and 2009 seasons

	Acidity %							
	2008 Season				2009 Season			
	Phase of spraying				Phase of spraying			
Treatments	Fruit set	Veraison	Fruit set+ Veraison	Mean	Fruit set	Veraison	Fruit set+ Veraison	Mean
Potassium thiosulfate 1.5 cm/L	0.73 ab	0.71 a-c	0.65 d-g	0.697 B	0.69 ab	0.66 a-d	0.61 c-f	0.653 BC
Potassium thiosulfate 2.5 cm/L	0.58 h-j	0.55 jk	0.52 kl	0.550 F	0.53 g-i	0.51 h-j	0.47 ij	0.503 EF
Potassium thiosulfate 3.5 cm/L	0.56 i-k	0.52 kl	0.49 l	0.523 F	0.50 h-j	0.47 i-j	0.44 j	0.470 F
Monopotassium phosphate 1.5 g/L	0.74 a	0.72 a-c	0.68 b-e	0.713 AB	0.70 a	0.66 a-d	0.65 a-d	0.670 B
Monopotassium phosphate 2.5 g/L	0.65 d-g	0.63 e-h	0.58 h-j	0.620 D	0.56 e-h	0.54 f-i	0.50 h-j	0.533 E
Monopotassium phosphate 3.5 g/L	0.61 g-i	0.58 h-j	0.55 jk	0.580 E	0.53 g-i	0.51 h-j	0.48 ij	0.507 EF
Amiphole potassium 1.5 cm/L	0.74 a	0.72 a-c	0.70 a-d	0.720 AB	0.72 a	0.68 a-c	0.67 a-c	0.690 AB
Amiphole potassium 2.5 cm/L	0.71 a-c	0.67 c-f	0.62 f-h	0.667 C	0.65 a-d	0.62 b-e	0.57 e-h	0.613 CD
Amiphole potassium 3.5 cm/L	0.67 c-f	0.70 a-d	0.59 h-j	0.653 C	0.61 c-f	0.59 d-g	0.54 f-i	0.580 D
Control	0.74 a	0.74 a	0.74 a	0.740 A	0.72 a	0.72 a	0.72 a	0.720 A
Mean	0.673 *A*	0.654 *B*	0.612 *C*	-	0.621 *A*	0.596 *B*	0.565 *C*	-

Mean separation by Duncan Multiple Range (0.05)

Table 5: Effect of conducted treatments on TSS / acidity ratio of Crimson Seedless grape at harvest during 2008 and 2009 seasons

	Total soluble solids / Acidity ratio							
	2008 Season				2009 Season			
	Phase of spraying				Phase of spraying			
Treatments	Fruit set	Veraison	Fruit set+ Veraison	Mean	Fruit set	Veraison	Fruit set+ Veraison	Mean
Potassium thiosulfate 1.5 cm/L	22.2 j	23.1 i	26.2 g	23.83 G	23.9 pq	25.5 m-o	28.5 kl	25.97 G
Potassium thiosulfate 2.5 cm/L	31.4 d	33.6 c	36.0 b	33.67 B	35.5 fg	37.6 d	41.3 b	38.13 B
Potassium thiosulfate 3.5 cm/L	33.4 c	36.5 b	39.2 a	36.37 A	39.0 c	42.1 b	45.5 a	42.20 A
Monopotassium phosphate 1.5 g/L	21.2 k	22.2 j	24.4 h	22.60 H	23.1 q	24.8 n-p	26.2 m	24.70 H
Monopotassium phosphate 2.5 g/L	26.5 g	28.1 f	31.0 d	28.53 D	31.8 ij	33.7 h	37.2 de	34.23 D
Monopotassium phosphate 3.5 g/L	29.0 e	31.4 d	33.5 c	31.30 C	34.0 gh	36.2 ef	39.1 c	36.43 C
Amiphole potassium 1.5 cm/L	21.6 jk	22.2 j	23.1 i	22.30 H	21.4 r	23.5 pq	24.6 op	23.17 I
Amiphole potassium 2.5 cm/L	23.1 i	24.9 h	27.7 f	25.23 F	26.0 mn	27.7 l	31.1 j	28.27 F
Amiphole potassium 3.5 cm/L	24.9 h	24.9 h	29.7 e	26.50 E	27.9 l	29.5 k	33.1 hi	30.17 E
Control	21.6 jk	21.6 jk	21.6 jk	21.60 I	22.8 q	22.8 q	22.8 q	22.80 I
Mean	25.49 *C*	26.85 *B*	29.24 *A*	-	28.54 *C*	30.34 *B*	32.94 *A*	-

Mean separation by Duncan Multiple Range (0.05)

thiosulfate at 3.5 cm/L induced significantly the least percentage of this parameter with insignificant differences from same treatment at medial concentration and the monopotassium phosphate treatment at 3.5 g /L in the second season. Interaction studies reveal that, least acidity percentages at both seasons were induced by potassium thiosulfate treatment at 3.5 cm/L when it was double sprayed or sprayed at the veraison stage with insignificant differences between them.

TSS/acid ratio was significantly the highest with the double sprays on the average (Table 5). Untreated berries attained significantly the least ratio. Whereas, statistically the highest ratio was due to potassium thiosulfate at 3.5 cm/L in both seasons. Interaction data illustrate that highest ratio statistically was induced by double sprays of potassium thiosulfate at 3.5 cm/L.

On the average double sprays resulted in significantly the highest percentage of total berry sugars (Table 6). Control attained on the average significantly the least berry total sugars percentage. Whereas, potassium thiosulfate at 3.5 cm/L resulted in statistically the highest percentage in both seasons of the investigation. The results attained by potassium thiosulfate at 2.5 cm/L in the first season and monopotassium phosphate at 3.5 g /L in the second one were statistically equal. Interaction studies show that, double sprays of potassium thiosulfate at 2.5 or 3.5 cm/L resulted in significantly the highest total sugar percentage in both seasons. The double sprays of monopotassium phosphate at 3.5 g /L were statistically equal in this respect in the second season only.

Table 6: Effect of conducted treatments on total sugars % of Crimson Seedless grape at harvest during 2008 and 2009 seasons

	Total sugars %							
	2008 Season				2009 Season			
	Phase of spraying				Phase of spraying			
Treatments	Fruit set	Veraison	Fruit set+ Veraison	Mean	Fruit set	Veraison	Fruit set+ Veraison	Mean
Potassium thiosulfate 1.5 cm/L	14.3 jk	14.8 g-i	15.2 g	14.77 E	14.7 m-o	15.3 i-m	15.8 g-i	15.27 D
Potassium thiosulfate 2.5 cm/L	14.8 g-i	16.2 d-f	17.0 ab	16.00 AB	15.4 i-l	16.7 d-f	17.6 ab	16.57 B
Potassium thiosulfate 3.5 cm/L	15.0 gh	16.4 c-e	17.4 a	16.27 A	15.6 h-j	17.1 b-d	18.2 a	16.97 A
Monopotassium phosphate 1.5 g/L	14.2 jk	14.8 g-i	15.2 g	14.73 E	14.5 no	15.2 i-m	15.7 h-j	15.13 DE
Monopotassium phosphate 2.5 g/L	14.6 h-j	16.0 ef	16.7 bc	15.77 BC	15.1 j-n	16.6 d-f	17.4 bc	16.37 BC
Monopotassium phosphate 3.5 g/L	14.8 g-i	16.2 d-f	16.8 bc	15.93 BC	15.4 i-l	16.9 c-e	17.6 ab	16.63 AB
Amiphole potassium 1.5 cm/L	14.2 jk	14.5 ij	14.8 g-i	14.50 E	14.4 o	14.8 l-o	15.2 i-m	14.80 E
Amiphole potassium 2.5 cm/L	14.5 ij	15.2 g	15.8 f	15.17 D	14.7 m-o	15.5 i-k	16.2 f-h	15.47 D
Amiphole potassium 3.5 cm/L	14.6 h-j	16.0 ef	16.5 cd	15.70 C	14.9 k-o	16.4 e-g	17.0 b-e	16.10 C
Control	14.0 k	14.0 k	14.0 k	14.00 F	14.3 o	14.3 o	14.3 o	14.30 F
Mean	14.50 *C*	15.41 *B*	15.94 *A*	-	14.90 *C*	15.88 *B*	16.50 *A*	-

Mean separation by Duncan Multiple Range (0.05)

Table 7: Effect of conducted treatments on total anthocyanin (mg/100g fw) of Crimson Seedless grape at harvest during 2008 and 2009 seasons

	Total anthocyanin (mg/100 gm)							
	2008 Season				2009 Season			
	Phase of spraying				Phase of spraying			
Treatments	Fruit set	Veraison	Fruit set+ Veraison	Mean	Fruit set	Veraison	Fruit set+ Veraison	Mean
Potassium thiosulfate 1.5 cm/L	44.3 i-k	44.8 g-j	45.2 f-i	44.77 EF	45.3 i-k	45.9 g-j	46.2 f-j	45.80 E
Potassium thiosulfate 2.5 cm/L	46.1 b-f	46.3 b-e	47.1 ab	46.50 B	46.6 e-g	49.3 ab	49.9 bc	48.29 A
Potassium thiosulfate 3.5 cm/L	46.8 a-d	46.9 a-c	47.6 a	47.10 A	46.7 e-g	49.4 ab	50.0 a	48.70 A
Monopotassium phosphate 1.5 g/L	43.8 j-l	44.3 i-k	44.9 g-i	44.33 FG	45.2 jk	45.7 g-j	46.3 f-i	45.76 E
Monopotassium phosphate 2.5 g/L	45.4 e-h	46.0 c-f	46.5 b-d	45.97 BC	46.3 f-i	49.0 a-c	47.6 de	47.63 BC
Monopotassium phosphate 3.5 g/L	45.8 d-g	46.2 b-f	46.8 a-d	46.27 BC	47.6 de	47.8 d	49.2 ab	48.20 AB
Amiphole potassium 1.5 cm/L	43.3 kl	43.6 kl	44.7 h-j	43.87 G	45.0 i-k	45.4 h-k	46.3 f-i	45.67 E
Amiphole potassium 2.5 cm/L	44.7 h-j	45.2 f-i	46.0 c-f	45.30 DE	45.8 g-j	46.4 f-h	47.2 d-f	46.47 D
Amiphole potassium 3.5 cm/L	45.2 f-i	45.8 d-g	46.4 b-e	45.80 CD	47.2 d-f	47.5 de	48.0 cd	47.57 C
Control	43.2 l	43.2 l	43.2 l	43.20 H	44.6 k	44.6 k	44.6 k	44.6 F
Mean	44.86 *C*	45.23 *B*	45.84 *A*	-	46.07 *C*	47.10 *B*	47.53 *A*	-

Mean separation by Duncan Multiple Range (0.05)

Table 8: Effect of conducted treatments on potassium% in the berries of Crimson Seedless grape at harvest during 2008 and 2009 seasons

	Potassium % (g/100 gm)							
	2008 Season				2009 Season			
	Phase of spraying				Phase of spraying			
Treatments	Fruit set	Veraison	Fruit set+ Veraison	Mean	Fruit set	Veraison	Fruit set+ Veraison	Mean
Potassium thiosulfate 1.5 cm/L	1.28 h-k	1.32 g-k	1.36 g-k	1.320 E-G	1.34 pq	1.39 n-p	1.44 l-n	1.390 G
Potassium thiosulfate 2.5 cm/L	1.67 c-f	1.74 e-h	2.20 ab	1.870 B	1.77 f	1.85 e	2.46 b	2.027 B
Potassium thiosulfate 3.5 cm/L	1.80 c-e	1.87 cd	2.37 a	2.013 A	1.91 d	1.98 c	2.63 a	2.173 A
Monopotassium phosphate 1.5 g/L	1.25 i-k	1.29 h-k	1.33 g-k	1.290 E-G	1.30 qr	1.35 o-q	1.40 m-o	1.350 H
Monopotassium phosphate 2.5 g/L	1.46 f-j	1.52 e-i	1.78 c-e	1.587 CD	1.54 ij	1.61 h	1.88 de	1.677 D
Monopotassium phosphate 3.5 g/L	1.60 d-g	1.67 c-f	1.93 bc	1.733 BC	1.69 g	1.77 f	2.03 c	1.830 C
Amiphole potassium 1.5 cm/L	1.18 jk	1.22 i-k	1.26 h-k	1.220 FG	1.22 st	1.27 rs	1.31 qr	1.267 I
Amiphole potassium 2.5 cm/L	1.32 g-k	1.38 f-k	1.44 f-k	1.380 EF	1.38 op	1.45 lm	1.52 jk	1.450 F
Amiphole potassium 3.5 cm/L	1.40 f-k	1.46 f-j	1.52 e-i	1.460 DE	1.47 kl	1.52 jk	1.59 hi	1.527 E
Control	1.15 k	1.15 k	1.15 k	1.150 G	1.18 t	1.18 t	1.18 t	1.180 J
Mean	1.411 *B*	1.462 *B*	1.634 *A*	-	1.480 *C*	1.537 *B*	1.744 *A*	-

Mean separation by Duncan Multiple Range (0.05)

Table 9: Effect of conducted treatments on weight loss % of Crimson Seedless grape after 30 days of cold storage during 2008 and 2009 seasons

	Weight loss % after 30 days of cold storage							
	2008 Season				2009 Season			
	Phase of spraying				Phase of spraying			
Treatments	Fruit set	Veraison	Fruit set+ Veraison	Mean	Fruit set	Veraison	Fruit set+ Veraison	Mean
Potassium thiosulfate 1.5 cm/L	10.7 cd	8.2 g-j	7.8 ij	8.90 D	12.4 bc	10.0 e-h	9.2 i-k	10.53 D
Potassium thiosulfate 2.5 cm/L	8.2 g-j	6.8 k-m	6.3 m	7.10 F	9.7 hi	7.4 o-q	7.0 pq	8.03 H
Potassium thiosulfate 3.5 cm/L	7.6 i-k	6.5 lm	5.3 n	6.47 G	8.7 k-m	6.8 qr	6.2 r	7.23 I
Monopotassium phosphate 1.5 g/L	11.3 bc	9.4 ef	8.2 g-j	9.63 C	12.8 b	10.6 e	9.8 g-i	11.07 C
Monopotassium phosphate 2.5 g/L	8.7 f-h	6.7 k-m	6.0 mn	7.13 F	10.5 ef	8.4 l-n	7.6 op	8.83 G
Monopotassium phosphate 3.5 g/L	8.2 g-j	7.3 j-i	6.8 k-m	7.43 EF	9.9 f-h	7.6 op	7.0 pq	8.17 H
Amiphole potassium 1.5 cm/L	11.7 ab	10.1 de	8.8 fg	10.20 B	13.0 b	11.7 d	10.4 e-g	11.70 B
Amiphole potassium 2.5 cm/L	9.8 de	8.5 f-i	7.8 h-j	8.70 D	12.0 cd	9.6 h-j	8.3 mn	9.97 E
Amiphole potassium 3.5 cm/L	9.3 ef	7.4 j-l	6.8 k-m	7.83 E	11.4 d	9.0 j-l	8.0 no	9.47 F
Control	12.6 a	12.6 a	12.6 a	12.60 A	14.2 a	14.2 a	14.2 a	14.20 A
Mean	9.81 *A*	8.35 *B*	7.64 *C*	-	11.46 *A*	9.53 *B*	8.77 *C*	-

Mean separation by Duncan Multiple Range (0.05)

On the average the double sprays treatment resulted in statistically the utmost effect concerning the berry anthocyanin content (Table 7). On the average all of the conducted treatments increased this pigments significantly compared with the control. Significantly the higher anthocyanin content was due to potassium thiosulfate treatment at 3.5 cm/L in both seasons and both potassium thiosulfate treatment at 2.5 cm/L monopotassium phosphate treatment at 3.5 g/L in the second season only. Interaction data declare that, highest anthocyanin content was due potassium thiosulfate treatment at 3.5 cm/L sprayed at the veraison stage or double sprayed in both seasons. In the first season, comparable results were due to potassium thiosulfate treatment at 3.5 cm/L sprayed at the fruit set stage. In the second season however, comparable results were as a result of veraison sprays of potassium thiosulfate treatment at 2.5 cm/L and monopotassium phosphate at 2.5 g/L in addition to double sprays of monopotassium phosphate at 3.5 g/L.

Effect of Conducted Treatments on Berry Content of Potassium: On the average berry content of potassium was significantly the highest with double sprays (Table 8). The considered treatments increased this content statistically when compared with control with the significantly the utmost effect attributed to the potassium thiosulfate treatment at 3.5 cm/L. Interaction data clarify that double sprays of potassium thiosulfate at 3.5 cm/L induced significantly the highest berry potassium content in both considered seasons. Medial concentration of potassium thiosulfate with double sprays resulted in an insignificantly different effect in the first season only.

Effect of Conducted Treatments on Fruit Quality after 30 Days Cold Storage: Double sprays resulted in the significantly the least weight loss percentage in both seasons (Table, 9). Potassium thiosulfate at its' higher concentration led to significantly the least percentage when compared with control and the remaining treatments. Interaction data show that in the first season double sprays of both potassium thiosulfate at 3.5 cm/L and monopotassium phosphate at 2.5 cm/L resulted in significantly the least weight loss percentage. In the second season however, significantly the utmost reduction was due to double sprays and veraison spray of 3.5% from potassium thiosulfate with insignificant differences between them.

Berry firmness was significantly the highest as a result of double sprays in both seasons (Table, 10). On the average sprays of potassium thiosulfate at 3.5 cm/L resulted in significantly the highest berry firmness when compared with control and the remaining treatments. Interaction data declare that statistically the firmest berries were dedicated to double sprays of potassium thiosulfate at 3.5 cm/L in both seasons.

On the average shattering percentage was significantly the least as a result of the double sprays (Table, 11). Spraying potassium thiosulfate at 3.5 cm/L in both seasons induced significantly the least shattering percentage in both seasons. In the second season however, comparable percentage was due to 2.5 cm/L sprays from the same compound. Interaction data show that double sprays of both medial and high concentrations of potassium thiosulfate induced the least shattering percentage.

Table 10: Effect of conducted treatments on firmness (g/cm2) of Crimson Seedless grape after 30 days of cold storage during 2008 and 2009 seasons

	Firmness after 30 days of cold storage							
	2008 Season				2009 Season			
	Phase of spraying				Phase of spraying			
Treatments	Fruit set	Veraison	Fruit set+ Veraison	Mean	Fruit set	Veraison	Fruit set+ Veraison	Mean
Potassium thiosulfate 1.5 cm/L	324.3 n	365.2 k	416.5 g	368.7 G	359.2 p	404.5 n	459.3 i	407.7 G
Potassium thiosulfate 2.5 cm/L	425.3 f	446.6 d	477.7 b	449.9 B	468.2 gh	493.4 e	528.5 b	496.7 B
Potassium thiosulfate 3.5 cm/L	446.3 d	467.5 c	498.6 a	470.8 A	490.4 e	515.3 c	550.7 a	518.8 A
Monopotassium phosphate 1.5 g/L	297.2 o	338.4 m	389.3 i	341.6 H	331.2 q	375.5 o	431.4 kl	379.4 H
Monopotassium phosphate 2.5 g/L	389.2 i	420.3 fg	461.4 c	423.6 D	427.4 l	462.6 hi	507.3 d	465.8 D
Monopotassium phosphate 3.5 g/L	394.3 i	425.5f	466.6 c	428.8 C	435.7 k	470.6 g	515.6 c	474.0 C
Amiphole potassium 1.5 cm/L	286.4 p	327.3 n	378.4 j	330.7 I	319.4 r	364.3 p	419.2 m	367.6 I
Amiphole potassium 2.5 cm/L	346.2 l	387.5 i	438.7 e	390.8 F	382.4 o	427.5 l	482.7 f	430.9 F
Amiphole potassium 3.5 cm/L	374.2 j	405.3 h	446.4 d	408.6 E	411.6 n	446.3 j	491.5 e	449.8 E
Control	254.6 q	254.6 q	254.6 q	254.6 J	286.4 s	286.4 s	286.4 s	286.4 J
Mean	353.8 *C*	383.8 *B*	422.8 *A*	-	391.2 *C*	424.6 *B*	467.3 *A*	-

Mean separation by Duncan Multiple Range (0.05)

Table 11: Effect of conducted treatments on shattering% of Crimson Seedless grape after 30 days of cold storage during 2008 and 2009 Seasons

	Shattering % after 30 days of cold storage							
	2008 Season				2009 Season			
	Phase of spraying				Phase of spraying			
Treatments	Fruit set	Veraison	Fruit set+ Veraison	Mean	Fruit set	Veraison	Fruit set+ Veraison	Mean
Potassium thiosulfate 1.5 cm/L	9.3 b	7.0 ef	6.7 fg	7.67 D	9.8 c	8.3 e-h	8.0 f-i	8.70 C
Potassium thiosulfate 2.5 cm/L	5.6 ij	4.7 kl	3.8 mn	4.70 G	6.4 lm	5.3 no	4.7 op	5.47 H
Potassium thiosulfate 3.5 cm/L	5.0 jk	4.3 lm	3.2 n	4.17 H	6.2 lm	5.0 d	4.0 p	5.07 H
Monopotassium phosphate 1.5 g/L	10.2 a	8.3 c	7.0 ef	8.50 C	10.6 b	9.0 de	8.4 e-g	9.33 B
Monopotassium phosphate 2.5 g/L	6.5 fg	4.6 kl	4.7 kl	5.27 F	7.3 i-k	6.2 lm	5.8 mn	6.43 F
Monopotassium phosphate 3.5 g/L	5.8 hi	5.2 i-k	4.2 lm	5.07 FG	6.7 kl	5.8 mn	5.3 no	5.93 G
Amiphole potassium 1.5 cm/L	10.6 a	9.0 b	7.6 de	9.07 B	11.2 ab	9.7 cd	8.8 g-i	9.90 B
Amiphole potassium 2.5 cm/L	8.2 cd	7.0 ef	6.7 fg	7.30 D	8.7 ef	7.6 h-j	6.9 j-l	7.73 D
Amiphole potassium 3.5 cm/L	7.1 ef	6.3 gh	5.7 hi	6.37 E	7.7 g-i	6.8 kl	6.3 lm	6.93 E
Control	10.6 a	10.6 a	10.6 a	10.60 A	11.4 a	11.4 a	11.4 a	11.40 A
Mean	7.89 *A*	6.70 *B*	6.02 *C*	-	8.60 *A*	7.51 *B*	6.96 *C*	-

Mean separation by Duncan Multiple Range (0.05)

Table 12: Effect of conducted treatments on TSS% of Crimson Seedless grape after 30 days of cold storage during 2008 and 2009 Seasons

	TSS % after 30 days of cold storage							
	2008 Season				2009 Season			
	Phase of spraying				Phase of spraying			
Treatments	Fruit set	Veraison	Fruit set+ Veraison	Mean	Fruit set	Veraison	Fruit set+ Veraison	Mean
Potassium thiosulfate 1.5 cm/L	16.8 k-m	17.0 j-m	17.9 f-j	17.23 E	17.3 k-n	17.7 h-k	18.2 e-h	17.73 F
Potassium thiosulfate 2.5 cm/L	18.7 d-g	19.2 b-d	20.1 ab	19.33 AB	19.0 cd	19.6 b	20.5 a	19.70 B
Potassium thiosulfate 3.5 cm/L	19.0 c-e	19.8 a-c	20.3 a	19.70 A	19.4 bc	20.2 a	20.6 a	20.07 A
Monopotassium phosphate 1.5 g/L	16.4 m	16.4 m	17.1 i-m	16.63 F	16.9 mn	17.4 j-m	17.9 g-j	17.40 G
Monopotassium phosphate 2.5 g/L	17.7 g-k	18.5 d-h	19.0 c-e	18.40 C	18.2 e-h	18.7 de	19.4 bc	18.77 D
Monopotassium phosphate 3.5 g/L	18.2 d-h	18.9 c-f	19.8 ab	18.97 B	18.5 d-f	19.0 cd	20.2 a	19.23 C
Amiphole potassium 1.5 cm/L	16.4 m	16.6 lm	16.7 k-m	16.57 F	16.9 mn	17.0 l-n	17.5 i-l	17.13 G
Amiphole potassium 2.5 cm/L	17.0 j-m	17.5 h-l	18.1 e-i	17.53 DE	17.7 h-k	18.0 f-i	18.3 e-g	18.00 EF
Amiphole potassium 3.5 cm/L	17.6 h-l	17.9 f-j	18.7 d-f	18.07 CD	17.5 i-l	17.9 g-j	18.9 cd	18.10 E
Control	16.4 m	16.4 m	16.4 m	16.40 F	16.7 n	16.7 n	16.7 n	16.70 H
Mean	17.42 *C*	17.82 *B*	18.41 *A*	-	17.81 *C*	18.22 *B*	18.82 *A*	-

Mean separation by Duncan Multiple Range (0.05)

Table 13: Effect of conducted treatments on acidity % of Crimson Seedless grape after 30 days of cold storage during 2008 and 2009 Seasons

Treatments	Acidity after 30 days of cold storage							
	2008 Season				2009 Season			
	Phase of spraying				Phase of spraying			
	Fruit set	Veraison	Fruit set+ Veraison	Mean	Fruit set	Veraison	Fruit set+ Veraison	Mean
Potassium thiosulfate 1.5 cm/L	0.65 a-d	0.64 a-e	0.61 a-g	0.63 AB	0.61 a-c	0.57 b-f	0.55 c-g	0.57 BC
Potassium thiosulfate 2.5 cm/L	0.50 h-l	0.50 h-l	0.41 lm	0.47 E	0.48 g-k	0.42 j-m	0.38 lm	0.43 DE
Potassium thiosulfate 3.5 cm/L	0.49 h-m	0.47 i-m	0.39 m	0.45 E	0.48 g-k	0.40 k-m	0.36 m	0.41 E
Monopotassium phosphate 1.5 g/L	0.67 a-c	0.64 a-e	0.62 a-g	0.64 AB	0.65 ab	0.60 a-d	0.58 a-e	0.61 AB
Monopotassium phosphate 2.5 g/L	0.56 d-j	0.57 c-i	0.46 j-m	0.53 D	0.54 c-h	0.48 g-k	0.43 lm	0.48 D
Monopotassium phosphate 3.5 g/L	0.54 e-k	0.53 f-k	0.44 k-m	0.50 DE	0.51 e-i	0.43 i-m	0.40 h-l	0.45 DE
Amiphole potassium 1.5 cm/L	0.68 ab	0.66 a-d	0.64 a-e	0.66 AB	0.65 ab	0.65 ab	0.60 a-c	0.63 A
Amiphole potassium 2.5 cm/L	0.63 a-f	0.61 a-g	0.57 c-i	0.60 BC	0.60 a-d	0.54 c-h	0.53 f-j	0.56 C
Amiphole potassium 3.5 cm/L	0.58 b-h	0.57 c-i	0.52 g-k	0.56 CD	0.57 b-f	0.51 e-i	0.49 d-i	0.52 C
Control	0.69 a	0.69 a	0.69 a	0.69 A	0.66 a	0.66 a	0.66 a	0.66 A
Mean	0.60 *A*	0.59 *A*	0.54 *B*	-	0.58 *A*	0.53 *B*	0.50 *B*	-

Mean separation by Duncan Multiple Range (0.05)

Table 14: Effect of conducted treatments on TSS% / acidity ratio of Crimson Seedless grape after 30 days of cold storage during 2008 and 2009 Seasons

Treatments	T.S.S/Acidity ratio after 30 days of cold storage							
	2008 Season				2009 Season			
	Phase of spraying				Phase of spraying			
	Fruit set	Veraison	Fruit set+ Veraison	Mean	Fruit set	Veraison	Fruit set+ Veraison	Mean
Potassium thiosulfate 1.5 cm/L	25.8 m-o	26.6 l-o	29.3 i-n	27.23 DE	28.4 n-p	31.1 j-n	33.1 i-m	30.87 FG
Potassium thiosulfate 2.5 cm/L	37.4 d-g	38.4 d-f	49.0 ab	41.60 A	39.6 fg	46.7 cd	53.9 ab	46.73 B
Potassium thiosulfate 3.5 cm/L	38.8 de	42.1 cd	52.1 a	44.33 A	40.4 ef	50.5 bc	57.2 a	49.37 A
Monopotassium phosphate 1.5 g/L	24.5 no	25.6 m-o	27.6 j-o	25.90 EF	26.0 op	29.0 n-p	30.8 k-n	28.60 GH
Monopotassium phosphate 2.5 g/L	31.6 h-l	32.5 g-j	41.3 cd	35.13 C	33.7 i-k	38.9 f-h	45.1 d	39.23 D
Monopotassium phosphate 3.5 g/L	33.7 f-i	35.7 e-h	45.0 bc	38.13 B	36.3 g-i	44.2 de	50.5 bc	43.67 C
Amiphole potassium 1.5 cm/L	24.1 o	25.2 no	26.1 m-o	25.13 EF	26.0 op	26.2 op	29.2 m-p	27.13 HI
Amiphole potassium 2.5 cm/L	27.0 k-o	28.7 i-o	31.8 h-k	29.17 D	29.5 l-o	33.3 i-l	34.5 i-k	32.43 F
Amiphole potassium 3.5 cm/L	30.3 i-m	31.4 h-l	36.0 e-h	32.57 C	30.7 k-n	35.1 h-j	38.6 f-h	34.80 E
Control	23.8 o	23.8 o	23.8 o	23.80 F	25.3 p	25.3 p	25.3 p	25.30 I
Mean	29.70 *B*	31.00 *B*	36.20 *A*	-	31.59 *C*	36.03 *B*	39.82 *A*	-

Mean separation by Duncan Multiple Range (0.05)

Juice TSS% was significantly the highest with the double sprays on the average (Table, 12). As for the average treatment effect, spraying potassium thiosulfate at 3.5 cm/L resulted in significantly the highest juice TSS % when compared with control and the remaining treatments.

Insignificant differences were attributed to potassium thiosulfate treatments at 3.5 cm/L in the first season only. Interaction studies show that significantly the highest juice TSS% was obtained due to double sprays of potassium thiosulfate at 3.5 cm/L. Results of same treatment sprayed at the veraison stage, double sprays of 2.5 cm/L from potassium thiosulfate and double sprays of 3.5 cm/L from monopotassium phosphate were insignificantly differed.

On the average, significantly the least juice acidity was due to the double sprays in both seasons of the investigation (Table, 13). Comparable results were conducted due to spraying at the veraison stage in the second season only. Compared with control and the remaining treatments significantly the least results were due to higher concentrations of potassium taken from potassium thiosulfate and monopotassium phosphate in addition to medial concentration of potassium taken from potassium thiosulfate with insignificant differences between them. Interaction data reveal that significantly the least juice acidity percentage was attributed to double sprays of highest or medial concentrations of potassium thiosulfate or monopotassium phosphate in both seasons. In the first season comparable results were as a result of spraying potassium thiosulfate at 3.5 cm/L at the fruit set or version stages. In the second season however, insignificant results were achieved as a result of spraying 2.5 or 3.5 cm/L of potassium thiosulfate at the veraison stage or 3.5 cm/L of monopotassium phosphate at the veraison stage

TSS/acid ratio was significantly the highest with the double sprays on the average (Table 14). Whereas, average treatment effect illustrate that spraying potassium thiosulfate at 3.5 cm/L resulted in significantly the highest ratio when compared with control. Insignificant differences were attributed by the potassium thiosulfate at 2.5 cm/L in the first season only. Interaction results illustrate that double sprays of potassium thiosulfate at 2.5 or 3.5 cm/L resulted in significantly the highest TSS/acid ratio in both considered seasons.

In general double potassium sprays induced effects that were significantly the highest concerning the assessed parameters. This was accompanied by highest levels of berry potassium. Previous studies by Omar and Abdelall [9]; Ali *et al.* [5]; Abd El-Razek *et al.* [31] pointed out the importance of potassium applications at the considered phenological stages i.e. setting and Veraison stages. Application at the former stage was found to lead to cell enlargement and application at the later stage was found to enhance sugar accumulation [21, 32-34]. The double sprays was associated with the utmost berry potassium content and this in our opinion verify its' utmost effect.

As a general trend all forms of potassium successfully improved the assessed quality and storage parameters. Superiority was dedicated to potassium thiosulfate and in general to highest concentration used i.e. 3.5 cm/L. This was accompanied by highest berry potassium concentration. This clarifies that potassium absorption is related to the source. These findings are in parallel with those attained by Omar and Abdelall [9]; Hassan *et al.* [10] and Zhenming *et al.* [11] concerning that, the source of potassium affects absorption.

In specific potassium thiosulfate increased the berry weight, Juice TSS%,juice TSS/acid ratio, total sugars and anthocyanin content which is highly related with the berry coloration as previously indicated by Ali *et al.* [5] and Abd El-Razek *et al.* [31]. Whereas, juice acidity was markedly decreased. These findings are similar with those previously attained by Omar and Abdelall [9] and Ali *et al.* [5].

In our opinion these enhancements are basically due effects induced by higher berry potassium concentrations as cell enlargements and sugars accumulation [8, 11, 32]. In addition to potassium effects on improving the berry tolerance to stresses [14,16]. Effects sulphur as better potassium absorption due to lowering the PH should be put into consideration [35, 36].

The best berry quality maintenance after cold storage in terms of least weight loss percentage, least acidity%, least percentage of shattering, highest TSS% and highest juice TSS/acid ratio was attributed to the potassium thiosulfate treatment. These findings go with those previously illustrated by Ali *et al.* [5] and Mohmed *et al.* [37].

These findings are possibly due the effect of potassium in diminishing the respiration rate, reducing the sugar consumption, maintaining the berry quality and retarding the senescence phase [5, 10, 32].

In conclusion double sprays at both the fruit set and veraison phenological stages resulted in the utmost potassium absorption and this was reflected on clear enchantments of berry quality and storability. Of the three potassium tested forms potassium thiosulfate was the best and this was verified by the utmost enhancements of both berry quality at harvest and maintenance of quality after cold storage. This was associated with highest berry potassium content at harvest leading to the afore mentioned enhancements in addition to effects attributed to sulphur.

REFERENCES

1. David, W.R., R. Tarailo and A.B. Sayed, 1995. Crimson Seedless: A new late maturity, Red Seedless grape. HortScince 30:1473-1474.
2. Cameron, I., 2001. Crimson seedless promise WA table grape boon. J. Agric., 42: 1-5.
3. Spayd, S.E., J.M Tarara, D.L. Mee and J.C. Ferguson, 2002. Separation of sunlight and temperature effects on the composition of *Vitis vinifera* cv Merlot beeries. Am. J. Enol. Viticult., 53: 171-182.
4. Peppi, M.C., M.W. Fidelibus and N. Dokoozlian, 2006. Abscisic acid application timing and concentration affect firmness, pigmentation and color of 'Flame Seedless' grapes. Hortic. Sci., 141: 1440-1445.
5. Ali, M.A., R.S. El-Gendy and F.M. El-Morsi, 2006. Study on the possibility of improving colouration of Crimson seedless grapes under desrt condition via the application of some treatments. A- spraying with potassium and ethephon. Bull. Fac. Agric., Cairo Univ., 57: 701-722.
6. Cantin, C.M., W.F. Matthew and H.C. Carlos, 2007. Application of abscisic (ABA) at veraison advanced red color development and maintained postharvest quality of Crimson Seedless grapes. Postharvest Biology and Technol., 46: 237-241.
7. Huang, X.G., Q. Wang and T.C. Zhao, 2000. Effect of potassium fertilizers for improving quality and production of fruit crops. J. Fruit. Sci., 17: 309-313.

8. Gao, J.F., H.B. Sun, Z.K. Zhao and X.B. Chen, 2001. Effects of gibberellin, borax and dihydro potassium phosphate (KH_2PO_4) on fruit development and quality of grape. Northern Hortic., 1: 22-23.
9. Omar, A.H. and A.H. Abdelall, 2005. Fertilation of Crimson Seedless grapevines with nitrogen and potassium. J. Sci. Mansoura Univ., 30: 7831-7842.
10. Hassan, A.H., A.M. Mansour and N.H. Samra, 2007. Studies concerning the effect of potassium and magnesium fertilization on bud behavior, yield and berry quality of Thompson Seedless grape. J. Agric. Sci. Mansoura Univ., 32: 2747-2758.
11. Zhenming, N., X. Xuefeng, W. Yi, L. Tianzhong, K. Jin and H. Zhenhai, 2008. Effects of leaf applied potassium gibberellins and source sink ratio on potassium absorption and distribution in grape fruits. Scientia Horti., 115: 164-167.
12. Ban, T., M. Ishimaru, S. Kobayashi, S. Shiozaki, N. Goto-Yamamoto and S. Horiuchi, 2003. Abscisic acid and 2,4-dichlorophenoxyactic acid affect the expression of anthocyanin biosynthetic pathway genes in 'kyoho' grape berries. J. Hortic. Sci. Biotechnol., 78: 586-589.
13. Brar, H.S., Z. Singh and E. Swinny, 2008. Dynamics of anthocyanin and flavonol profiles in the Crimson Seedless grape berry skin during development and ripening. Scientia Hort., 117: 349-356.
14. Marschner, H., 1995. Functions of mineral nutrients: macronutrients. In: Marschner H (ed) Mineral nutrition of higher plants, 2nd ed. Academic, N.Y, pp: 299-312.
15. Martin, P., R. Relgado, M.R. Gonzlalez and J.I. Gallegos, 2004. Colour of 'Tempranillo' Grpaes as affected by different nitrogen and potassium fertilization rates. Proc. 1st international Symposium on Grapevine Growing Commerce and Research, Lisbon, Portugal. Acta. Hort., 652: 153-159.
16. Cakmak, I., 2005. The role of potassium in alleviating detrimental effects of abiotic stresses in plant. J. Plant Nutr. Soil. Sci., 168: 521-530.
17. Lester, G.E., J.L. Jifon and G. Rogers, 2005. Supplemental foliar potassium applications with or without a surfactant can enhance netted muskmelon quality. Hort Sci., 41: 741-744.
18. Lester, G.E., J.L. Jifon and D.J. Makus, 2006. Supplemental foliar potassium application with or without a surfactant can enhances netted muskmelon quality. Horti. Sci., 41: 741-744.
19. Kanai, S., K. Ohkura, J.J. Adu-Gyamfi, P.K. Mohapatra, N.T. Nguyen, H. Saneoka and K. Fujita, 2007. Depression of sink activity precedes the inhibition of biomass production in tomato plant subjected to potassium deficiency stress. J. Experimental Bot., 58: 2917-2928.
20. Yu, D.R., F.Y. Meng, X.Y. Cao, X.G. Lin, Y.Z. Deng, Y.L. Wang and K.J. Sun, 1994. Nutrient diagnosis in vitis amurensis Rupr. Plants and in soil. J. Soil Sci., 15: 169-170.
21. Hiratsuka, S., H. Onodera, Y.K. Kawai, T.H. Itoh and R. Wada, 2001. ABA and sugar effects on anthocyanin formation in grape beery cultured *in vitro*. Sci. Hortic., 90: 121-130.
22. Brady, N.C. and R.R. Weil, 1999. The Nature and Properties of Soils 9th Edition. Macmillan Publishing Company, New York, pp: 750.
23. Mortvedt, J.J.(2001). Calculating Salt Index. Fluid. J., 9: 8-11.
24. Bussakorn, S.M., P.S. Daniel, T.T. Michael and R.T. Mark, 2003. A review of potassium in grapevines with special emphasis on beery accumulation. Aust. J. Grape Wine Res., 9: 154-168.
25. A.O.A.C., 1985. Association of Official Analytical Chemists Official methods of analysis 14th Ed. Washington. D. C., USA. pp: 382.
26. Smith, F., M.A. Gilles, J.K. Hamilton and P.A. Godess, 1956. Colorimetric method for determination of sugars related substances. Anal. Chem., 28: 350-356.
27. Husia, C.L., B.S. Luh and C.D. Chichester, 1965. Anthocyanin in free stone peach. J. Food. Science, 30: 5-12.
28. Brown, J.D. and O. Lilleland, 1946. Rapid determination of potassium and sodium in plant material soil extract by flamephotometer. Proc. Amer. Soc. Hort. Sci., 48: 341-346.
29. Snedecor, G.W. and W.G. Cachran, 1980. Statistical methods. Oxford and J. B. H. publishing com. 6th edition.
30. Duncan, D.B., 1955. Multiple ranges and multiple F test. Biometrics, 11: 1-42.
31. Abd El-Razek, E., D. Treutter, M.M.S. Saleh, M. El-Shammaa, A.A. Fouad and N. Abdel –Hamid, 2011. Effect of nitrogen and potassium fertilization on productivity and fruit quality of Crimson Seedless grape. Agric. Biol. J. N. Am., 2: 330-340.
32. Davies, C., S. Ryoung, L. Weihong, R. Mrke and P. Daniel, 2006. Transporters expressed during grape berry (*Vitis vinifera* L)development are associated with an increase in berry size and berry potassium accumulation. J. Experimental Botany, 57: 3209-3216.

33. Pratelli, R., B. Lacombe, L. Torregrosa, F. Gaymard, C. Romieu, J.B. Thobaud and H. Sentenac, 2002. A grapevine gene encoding a guard cell k^+ channel displays development regulation in the grapevine beery. Plant Physiol., 128: 564-577.
34. Very, A.A. and H. Sentenac, 2003. Molecular mechanisms and regulation of K^+ transport in higher plants. Annual Review of Plant Biol., 54: 575-603.
35. Scherer, H.W. 2001. Sulpher in crop production. European J. Agronomy, 14: 81-111.
36. Moreira, N., F. Mendes, O. Pereira, P. Guedes de Pinho, T. Hogg and I. Vasconcelos, 2002. Volatile sulpher compounds in wines related to yeast metabolism and nitrogen composition of grape musts. Analytica Chimica Acta, 458: 157-167.
37. Mohmed, M.A.A., A.A. Gaser and A.A. Abd El-Ghany, 2007. Influence of seaweed extract (Acadian), EDTA calcium, ascorbic acid and gibberellic acid pre harvest application on Crimson Seedless table grape. II: storability. Egypt. J. Agric. Res., 85: 2257-2277.