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Improving Bunch and Berry Quality of Crimson Seedless Grape CV. Using Gibberellic Acid

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A FIELD experiment was carried out through two successive seasons of 2012 and 2013 on 8- years- old Crimson Seedless vine grown at 2.5 x 1.5 m apart in clay soil under drip irrigation system in a private vineyard located in Sharkia Governorate, Egypt. Grapevines were sprayed with GA_3 at 0.0, 0.5, 1.0, 2.0 and 4.0 mg/l at full bloom (80 % calyptra fall) to evaluate the effect of GA_3 as a thinning agent instead of hand thinning.

The obtained results markedly reveal that number of berries /bunch, bunch weight, yield/ vine, bunch compactness and berry compression force were significantly reduced with increasing GA_3 concentration. As an average of both seasons, number of berries/ bunch was decreased by 43.92, 62.44, 69.98 and 80.22 % as a result of spraying vines with GA_3 at 0.5, 1.0, 2.0 and 4.0 mg/l, respectively in comparison with the control treatment. The corresponding reduction percentage in yield/ vine was 33.77, 54.25, 61.75 and 70.9 %, respectively. In contrast, weight of 100 berries, berry removal force were obviously increased with increasing GA_3 concentrations in both seasons, due,

mainly, to increasing thinning level. Total soluble solid percentage (TSS%) and TSS/acid ratio were significantly increased as a result of GA_3 spraying treatments without significant differences between the tested concentrations in most cases, whereas total acidity percentages were reduced as compared with unsprayed vines in both seasons.

The obtained result of this study reveal that spraying GA_3 at 0.5 mg/l at full bloom was the optimum treatment for Crimson Seedless berry thinning, since this treatment obviously improved bunch and berry physical and chemical characteristics, as well as packable yield of tested table grape cv. without higher reduction in number of berries/ bunch, as well as yield and bunch weights as compared with the other tested GA_3 concentrations and control.

Keywords: Crimson Seedless, Thinning, GA_3, Bunch compactness, Berry quality and Yield.

Grape (*Vitis vinifera* L.) is considered one of the most important and popular fruit crops in the world, it ranks fourth after citrus, mango and olive in Egypt (FAO, 2012). Crimson Seedless grapes reach marketable quality in Egypt between mid-September and Late October, according to the applied agriculture practices.

Crimson Seedless is a late-ripening, red seedless table grape developed by the U.S. Department of Agriculture Horticultural Crops Research Laboratory at Fresno, California, (Ramming *et al*., 1995). Crimson Seedless grapes has superior eating characteristics, berry texture is crispy and firm more over its flavor is excellent with high TSS or Brix ratio at harvest.

Seedless table grapes are commercially attractive fruits with high consumer demand .Generally, the main problem in the production of seedless table grapes, is that naturally producing compact bunches which lead to huge bunches ,small berries, poor berry coloration and berry bunch rot. Without berry thinning the berries will not reach the acceptable commercially size and color.

Some berry and bunch characteristics as berry size and number of berries/ bunch are limiting factors for their suitability of exportation. The value in marketing of Crimson Seedless table grapes depends on the homogeneity of berries red color as well as bunch, berry size and shape. Exportation of

Crimson Seedless grape cv. depends on manual berry thinning which is very costly and can be considered one of the main limiting factors.

The exogenous treatment of various plant hormones to improve and develop fruits clears its important role in fruit development and improving quality characteristics (Srivastava and Handa, 2005). Gibberellins are widely used to increase bunch and berry weight and size, as well as yield/ vine in seedless grape cvs. (Ezzahouani *et al*., 1985) on Thompson Seedless and Ruby Seedless, (Orth, 1990b) on Muscat Seedless, (Wolf *et al*., 1994) on Flame Seedless and (Colapietra *et al*., 1995) on Centennial Seedless. It is commonly applied during bloom to reduce fruit set and bunch compactness of Flame Seedless and Thompson Seedless cvs. In addition, the use of GA_3 for thinning and/or berry enlargement may affect budburst and bud fertility negatively the following year (Orth, 1990a). According to different investigators, GA_3 generally, cause a reduction in flower set due to causing flowers to fall (Daulta *et al*., 1983, Pishbin & Dehlavi, 1983, Kushal *et al*., 1985 and Orth, 1990 b).

Some problems are associated with the production of Crimson Seedless grapevines such as achieving the desired level of red color and the excessive berry set which leads to compact big bunches with small berries, bunch rot (Dokoozlian *et al*., 1995). Hand thinning needs skilled workers and takes time so, is very costly. Gibberellic acid (GA_3) generally is used during flowering to reduce bunch compactness and flower number in seedless table grape in addition, to increasing berry size. The suitable GA_3 concentration differs among grape cultivars so, there is a need to specific recommendations for each cultivar in each cultural region.

The purpose of this study is to define the best GA_3 concentration for reducing Crimson Seedless grape flowers, obtaining loose grape bunches with high quality characteristics.

Materials and Methods

The present investigation was carried out during two successive seasons of 2012 and 2013 on 8-year-old Crimson Seedless grapevines grown in a private vineyard at Sharkia governorate, Egypt (30°38'3.38"N and 31°31'27.72"E) Attitude and longitude . The experimental vines were selected to be healthy and nearly similar in growth vigor and uniformly received the normal cultural practices. The selected vines were planted at 1.5 x 2.5 m apart. The vines were grown in clay soil under drip irrigation system and trellised on Spanish Baron system. Vines were trained according to the cane pruning system leaving around 70 buds/vine (*i.e*. 7 fruit canes x10 buds/ cane).

All experimental vines were adjusted to 25 cluster/vine and all clusters were tipped to approximately 16 cm length after fruit set. The selected vines were sprayed by the prepared solutions of GA_3 in the most common date of application (80% calyptras fall) early in the morning. The following spraying treatments were applied on bunches:

1- 0.0 mg/l (sprayed with tap water only as a control treatment), 2- GA_3 at 0.5 mg/l, 3- GA_3 at 1.0 mg/l, 4- GA_3 at 2.0 mg/l , 5- GA_3 at 4.0 mg/l.

At harvesting time when bunches reached maturity (16th and 14th September in the first and second season, respectively), bunches of each vine were picked and the yield/ vine (kg) was recorded.

Five bunches per replicate were randomly taken and the following determinations were carried out: bunch weight, number of berries/bunch and bunch compactness. Bunch compactness was estimated according to (Lynn and Jensen, 1966) as follows, the first four apical shoulders in the bunch from eight clusters selected randomly from each vine (two bunches per each cordon arm, total of thirty two shoulders per vine) were selected at harvest time. Number of all berries on each shoulder and total shoulder length were recorded, and used to calculate the number of berries per each (cm) shoulders length.

In addition, berry physical characteristics were assessed by randomly selection: 100 berries from each bunch sample (5 bunches per replicate) and then 100 berry weight was recorded. Berry removal force and berry compression force, were determined in thirty berries using a push pull dynamometer (Model FD101) and expressed as (g/cm^2). The berry polar diameter and length (cm) were measured, random 30 berries sample per each replicate using Vernier caliper. The berry shape index**,** i.e. length/width was calculated.

Moreover, the berry chemical constituents were determined in berry juice after being extracted from 100 berries representing each replicate as follows, the total soluble solids percentage (TSS %) using a hand refractometer. The juice acidity was determined by titration against sodium hydroxide (0.1 N) in the presence of phenolphythalyne as an indicator. The total juice acidity was expressed as g tartaric acid per 100 ml of juice. The TSS/acid ratio of each juice sample was then calculated (A.O.A.C. 1980).

Statistical Analysis

This experiment was set in a completely randomized block design with 5 treatments, each treatment was applied on three vines (three replicates)

The obtained data were subjected to analysis of variances (ANOVA) according to Snedecor and Cochran (1982) using CoStat program. The individual comparisons between the obtained values were carried out using LSD at 5% level.

Results and Discussion

Yield and bunch characteristics

Number of berries per bunch

The tested treatments affected the number of berries per bunch significantly in both seasons, (Table 1). The uppermost berry number/bunch 183.2 in the first season and in the second season 174.9 resulted from control treatment (untreated vines). The lowermost values 39.6 and 31.4 were attained by GA_3 at 4 mg/l treatment in the two seasons, respectively. The other treatments came in between. As an average of both seasons, berry number /bunch was recorded 44.8, 62.4,

TABLE 1. Effect of GA_3 spraying at full bloom on number of berries/bunch, bunch weight, compactness and yield of Crimson Seedless table grapes (2012 & 2013 seasons).

Treatment (GA_3 concentrations mg/l)	Number of berries/bunch		Bunch weight (g)		Compactness		Yield (kg)	
	2012	2013	2012	2013	2012	2013	2012	2013
0.0 (Control)	183.2	174.9	758.0	725.3	2.8	2.9	18.80	18.01
0.5	93.3	104.1	464.6	517.8	2.0	1.9	11.52	12.82
1.0	70.8	63.8	357.9	323.0	1.7	1.5	8.84	8.01
2.0	50.4	56.0	270.9	299.2	1.3	1.3	6.68	7.38
4.0	39.6	31.4	241.5	193.6	1.0	1.1	5.94	4.79
LSD 0.05	15.75	11.75	33.91	45.0	1.21	1.18	1.36	1.95

70.2 and 80.2 % as a result of spraying vines with GA_3 at 0.5, 1.0, 2.0 and 4.0 mg/l, respectively. This means that number of berries/ bunch was obviously decreased with increasing GA_3 concentrations.

The reduction in number of berries/bunch due to GA_3 sprays is in line with those found by Lecointre and Badier (1989), Dokoozlian *et al.* (2001) on Autumn Royal table grapes and Gonzaga and Ribeiro (2009) on Superior seedless.

Bunch weight

All GA_3 treatments significantly reduced bunch weight compared to the unsprayed vines (control) in both seasons, (Table 1). Bunch weight, generally, ranged between 241.5 to 758.0 g in the first season and from 193.6 to 725.3 g in the second season. The heaviest and the lightest bunches came from control and

GA_3 at 4 mg/l treatments, respectively in the two seasons. The data declare significant differences between the tested GA_3 concentrations in most cases. Bunch weight was markedly reduced with increasing GA_3 concentrations in most cases. The average of this decrements reached 33.6% at 0.5 mg/l, 54.1% at 1 mg/l, 61.5% at 2 mg/l and 70.7% at 4 mg/l in both seasons, respectively. The reduction in bunch weight as a result of GA_3 sprays was in harmony with those stated by Murisier (1988), Lecointre & Badier (1989) and Ali *et al.* (2006) on Crimson Seedless and Dokoozlian *et al.* (2001) on Autumn Royal table grapes.

Bunch compactness

The tested treatments significantly affected bunch compactness in both seasons, (Table 1). Bunch compactness values, ranged between 1.0 - 2.8 in the first season and 1.1 - 2.9 in the second one (Table 1). The uppermost values (2.8 and 2.9) were recorded for untreated (control) in both seasons, respectively. On the other hand, the lowermost values (1.0 in the first season and 1.1 in the second one) resulted from GA_3 at 4.0 mg/l treatment. Bunch compactness was reduced as GA_3 concentration increased. The reduction in bunch compactness due to GA_3 sprays was in line with Lecointre and Badier (1989) on 7 grapevines cvs. and Ozaki and Ichii (1992) on Campbell Early cv., Dokoozlian *et al.*, (2001) on Autumn Royal table grape, Gonzaga and Ribeiro (2009) on Superior seedless and Marzouk and Kassem (2011) on Thompson Seedless table grape.

Yield per vine

The tested treatments significantly affected yield/vine in both seasons (Table 1). It is clear that the highest yield/vine in the first and second seasons was obtained by the unsprayed vines (control). On the other hand, the lowermost values were recorded by GA_3 at 4.0 mg/l in the both seasons. The other treatments resulted in medium values . The data show also significant differences between the tested concentrations of GA_3 in most cases. It is obviously clear that yield/vine was markedly decreased with increasing GA_3 concentration. It was reduced by 38.72 and 28.82% at 0.5 mg/l, 52.97 and 55.52% at 1.0 mg/l, 64.47 and 59.02% at 2.0 mg/l and 68.40 and 73.40 % at 4.0 mg/l in the first and second season, respectively. The depressive effect of GA_3 on yield/vine was in agreement with Lecointre and Badier (1989) on 7 grapevine cvs. , Ozaki and Ichii (1992) on Campbell Early cv. and Dokoozlian *et al.* (2001) on Autumn Royal table grapes.

Chemical constituents of berry juice

Total soluble solids (TSS)

Data in Table 2, clear that the tested GA_3 treatments significantly affected TSS percentage in both seasons. The lowermost TSS percentages (16.5%) in the first season and (17.0%) in the second one were recorded for control treatment. The tested GA_3 concentrations induced TSS percentages without significant differences among in both seasons, except that 0.5 mg/l treatment in the first season. The obtained results were in line with those reported by Dokoozlian *et al*., (2001) on Autumn Royal table grapes and Marzouk and Kassem (2011) on Thompson Seedless table grape

Total titratable acidity

As shown in Table 2, there are significant differences between the tested GA_3 concentrations in both seasons. However, untreated vines (control treatment) recorded the highest total titratable acidity percentage 0.62% and 0.63% in both seasons, respectively, discerningly followed by those treated by GA_3 at 0.5 mg/l (0.58 and 0.59%) in the two seasons, respectively. The lowermost value 0.52% in the first season and 0.53% in the second one, were recorded by GA_3 at 4.0 mg/l without significant differences between those sprayed by GA_3 at 1.0 and 2.0 mg/l in the two seasons.

TABLE 2. Effect of GA3 spraying at full bloom on total soluble solids, acidity and TSS/acid ratio of Crimson Seedless table grapes (2012 & 2013 seasons).

Treatment (GA_3 concentrations (mg/l)	TSS (%)		Acidity (%)		TSS/acid ratio	
	2012	2013	2012	2013	2012	2013
0 (Control)	16.5	17.0	0.62	0.63	26.6	27.0
0.5 mg/l	18.5	19.0	0.58	0.59	31.9	32.2
1.0 mg/l	20.0	20.0	0.56	0.56	35.8	35.8
2.0 mg/l	20.5	20.3	0.54	0.55	38.0	37.2
4.0 mg/l	21.0	20.7	0.52	0.53	40.4	39.1
LSD 0.05	0.036	0.039	3.98	5.46	0.26	0.20

TSS/acid ratio

It is evident from Table 2, that GA_3 at 4.0 mg/l resulted in the highest TSS/acid ratio (40.4 and 39.1 in the first and second seasons, respectively) without significant differences from those recorded by 1.0 and 2.0 mg/l treatment in both seasons. The least TSS/acid ratio (26.6 and 27.0 in the first and second seasons), respectively were recorded for control treatment. The other treatments indicated in between values.

Generally, the obtained results show increasing effect of GA_3 as the concentrations increased on juice TSS percentage and TSS/acid ratio accompanied with a reduction in acidity percentage compared with control treatment. The increasing effect in TSS% by GA_3 treatments is in line with Dokoozlian *et al*. (2001) on Autumn Royal table grapes.

Berry physical characteristics

Weight of 100 berries

The obtained data in Table 3, declare significant effect of the tested treatments on weight of 100 berries in the two seasons. The weight of 100 Crimson Seedless berries, generally, ranged from 389.5 - 568.5 g in the first season and 397.0 to 563.2 g in the second one. GA_3 at 4.0 mg/l gave the highest 100 berry weight (568.5 and 563.2 g) in both seasons, respectively. The lowest values (389.5 g in the first season and 397.0 g in the second one) were recorded with the control treatment. The other treatments came in between values without significant differences in both seasons. Weight of 100 berries was markedly increased with increasing GA_3 concentrations due mainly to increasing thinning level. These findings were in agreement with those reported by Casanova *et al*. (2009) on Emperatriz Seedless table grape and Marzouk and Kassem (2011) on Thompson Seedless table grape.

Berry removal force

Data in Table 3, show that the tested GA_3 treatments significantly affected berry removal force in both seasons. The obtained values, generally, ranged between 668.2 – 841.0 g/cm^2 in the first season and 643.1 to 853.0 g/cm^2 in the second one.

TABLE 3. Effect of GA3 spraying at full bloom on weight of 100 berries, berry removal force, berry compression force, berry dimensions and berry shape index of Crimson Seedless table grapes (2012 & 2013 seasons).

Treatments (GA_3 conc. mg/l)	Weight of 100 berries (g)		Berry removal force (g/cm^2)		Berry compression force (g/cm^2)		Berry Length (cm)		Berry width (cm)		Berry shape index	
	2012	**2013**	**2012**	**2013**	**2012**	**2013**	**2012**	**2013**	**2012**	**2013**	**2012**	**2013**
0 (Control)	389.5	397.0	668.2	643.1	332.4	344.2	2.20	2.22	1.62	1.60	1.37	1.41
0.5 mg/l	481.1	479.2	723.8	709.6	314.0	329.1	2.36	2.34	1.88	1.90	1.26	1.24
1.0 mg/l	475.6	470.3	748.6	751.4	302.4	308.0	2.40	2.41	1.90	1.92	1.27	1.26
2.0 mg/l	490.2	498.5	834.1	821.3	282.5	292.4	2.44	2.46	1.98	1.97	1.25	1.25
4.0 mg/l	568.5	563.2	841.0	853.0	278.1	260.2	2.50	2.61	2.00	2.10	1.25	1.26
LSD 0.05	9.99	9.99	18.93	22.30	26.24	27.67	0.16	0.41	0.39	0.35	0.25	0.41

The highest berry removal force in the two seasons (841.0 and 853.0 g/cm^2) resulted from GA_3 at 4.0 mg/l, respectively. On the other hand, the lowest values in both seasons (668.2 - 643.1 g/cm^2) were recorded for control treatment in the two seasons, respectively.

These findings are in agreement with those reported by Marzouk and Kassem (2011) on Thompson Seedless table grape.

Berry compression force

The tested treatments affected berry compression force significantly in both seasons (Table 3). Berry compression force generally, ranged from 278.1 - 332.4 g/cm^2 in the first season and 260.2 - 344.2 g/cm^2 in the second one. The highest and lowest values in the two seasons were recorded for control and GA_3 at 4.0 mg/l treatments, respectively.

Berry compression force was markedly reduced with increasing GA_3 concentration. So, berry compression force of 4.0 mg/l GA_3 treated vines was reduced by 16.33 and 24.4% as compared with those of control treatment in both seasons, respectively.

Berry dimension and berry shape index

The tested treatments revealed insignificant effects on berry dimensions (length, diameter and shape index) in the two seasons except those of berry length in the first season and berry width in the second one, Table 3. Weight of 100 berries was markedly increased with increasing GA_3 concentrations due mainly to increasing thinning level. These results are in harmony with those found by , El-Hodairi *et al*. (1995) and Dokoozlian *et al*. (2001) who reported that GA_3 treatments had no effect on berry dimensions (length and width).

Discussion

In this research and according to the obtained results, the tested GA_3 concentration exhibited significant differences between the obtained berry number/bunch in the two seasons. The higher GA_3 concentrations gained lower number of berries/bunch Dokoozlian *et al*. (2001) and Gonzaga & Ribeiro (2009).

Spraying GA_3 induces competitions for nutrient between shoots and flowers or among flowers within the same bunch. It means, flower thinning is caused due to a decrease in the available amount of nutrients for flowers growth and develop. Also, GA_3 increases the transfer rate of nutrients to the sprayed plant organ (Gil *et al*., 1994).

Bunch weight was markedly reduced with increasing GA_3 concentrations. The higher GA_3 concentration achieved lower bunch compactness values. Weight of 100 berries was significantly increased with increasing the concentration of GA_3 mainly due to increasing thinning level for bunch berries, (Casanova *et al*., 2009). Light cropping trees in all cases produce fruits with larger cells and consequently larger weight and size than do small fruits produced from heavy cropping ones (Ouma, 2010).The reduction of vine yield is commenced by the increase of price under exportation condition. At the same time, thinning treatments increases the available carbohydrates which is responsible for increasing fruit weight and size (Agusti *et al*., 2000). The treatment of GA_3 generally and at 0.5 mg/l at full bloom achieve many promising effects, it reduce the need for hand thinning minimally. It means, that treatment improve the quality of Crimson Seedless grapes through decreasing the bunch compactness and increasing TSS, Mainly because thinning treatments changed the leaf /fruit ratio, thus, there were more number of leaves per each bunch, which support fruit growth and reduce the competition between the remainder fruits for the available photo assimilates (Palmer *et al*., 1997).

In general, decreasing the remaining berries early in the growing season, can lead to increasing berry size and weight by allowing it to ripe quickly. The obtained results of this study show that spraying 0.5 mg/l GA_3 at full bloom (80% calyptra fall) was the optimum treatment for Crimson Seedless berry thinning. Since this treatment significantly reduced number of berries/ cluster, main cluster weight, bunch compactness, total yield and berry compression force but, increased weight of 100 berries (g), berry removal force (g/cm^2) and improved the packable yield quality of Crimson Seedless table grape, Marzouk and Kassem (2011).

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تحسين جودة عناقيد وحبات العنب كريمسون عديم البذور باستخدام حامض الجبريلك

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اجريت هذه الدراسة لمدة موسمين متتالين٢٠١٢ ، ٢٠١٣ على كرمات عنب صنف كريمسون سيدلس عمرها ٨ سنوات بمزرعة خاصة محافظة الشرقية ، والمزروعة فى التربة الطميية وتروى بنظام الرى بالتنقيط ومزروعة على مسافة ٢,٥*١,٥ متر .وقد تم معاملة النباتات بحامض الجبريليك بتركيز(٠ ، ٠,٥ ، ١,٠ ، ٢,٠ ، ٤,٠) مم/اللتر عند قمة التزهير (عند تفتح ٨٠٪ من الازهار) بهدف عمل خف للازهار باستخدام حامض الجبريلك بدلا من استخدام الخف اليدوى.

وتشير النتائج التي تم الحصول عليها الى ان معاملات حامض الجبريلك ادت لحدوث نقص معنوي في عدد الحبات/ عنقود ، وزن العنقود ، تزاحم العنقود، وقوة الصلابة وذلك مع زيادة تركيزات حامض الجبريلك .

وكمتوسط عام للموسمين وجد ان عدد الحبات/ عنقود حدث له نقص معنوي بنسبة :
٤٣,٩٢ ، ٦٢,٤٤ ، ٦٩,٩٨، ٨٠,٢٢٪ للنباتات التي تم رشها بحامض الجبريلك بتركيز ٠,٥ ، ١، ٢ ، ٤ مجم/ لتر على التوالي وذلك مقارنةً بمعاملة المقارنة .

وقد كانت نسبة النقص في المحصول/ كرمة ٣٣,٧٧ ٪ ،٥٤,٢٥٪ ،٦١,٧٥٪ ،٧٠,٩٪ على التوالى وعلى العكس مما سبق وجدت زيادة معنوية في وزن ال١٠٠ حبة ،قوة الشد للحبات مرتبطة مع زيادة تركيز حامض الجبريلك المستخدم خلال موسمي الدراسة ،هذه الزيادة ترجع بصورة اساسية الى زيادة درجة خف الحبات.

ولم تتأثر ابعاد الثمرة (الطول ، القطر ، نسبة الطول الى القطر) بمعاملات حامض الجبريلك خلال موسمي الدراسة.

وقد حدثت زيادة غير معنوية في نسبة المواد الصلبة الذائبة ،نسبة المواد الصلبة الذائبة/الى الحموضة بين المعاملات المختلفة في معظم المعاملات في حين حدوث نقص في نسبة الحموضة الكلية خلال موسمي الدراسة.

وتظهر النتائج المتحصل عليها من هذه الدراسة ان المعاملة بحامض الجبريلك بتركيز ٠,٥ مجم/لتر عند قمة التزهير كانت المعاملة الافضل لثمار العنب صنف كريمسون سيدلس حيث ادت هذه المعاملة الى تحسين واضح في صفات الثمرة الفيزيائية والكيميائية وكذلك المحصول القابل للجمع بدون حدوث نقص كبير في عدد الحبات /عنقود وكذلك وزن الغنقود عند المقارنة بباقي التركيزات المستخدمة من حامض الجبريلك ومعاملة المقارنة .