Jordan Journal of Agricultural Sciences, Volume **12**, No.**4** 2016

Effect of GA3 Concentration and Frequency on Yield and Quality of 'Zark' Grape

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ABSTRACT

A field experiment was carried out in a private vineyard located at Kamaki village, Duhok governorate, Kurdistan region, Iraq, during 2012 growing season to investigate the effect of four concentrations (0, 10, 20 and 30 ppm) and three frequencies (single, double and triple) of GA_3 on yield and quality of 'Zark' grapes. The results indicated that GA_3 concentration and frequency significantly affected most studied traits. Increasing concentration and frequency of GA_3 tended to increase yield per vine in term of number of clusters, cluster weight, number of berries per cluster and size of 100 berries. Juice percentage and density, total soluble solids, total sugars were also increased. However, total acidity and total phenols were significantly reduced. Weight of 100 berries was significantly affected only by increasing GA_3 concentration. The interaction between 30 ppm GA_3 and spraying triple surpassed all the traits studied in this investigation except size of 100 berries, total acidity and total phenols.

Keywords: Grape, GA3, concentration, frequency, yield, quality.

INTRODUCTION

Among the fruits, grape (*Vitis vinifera* L.) occupies first position in the world with respect to area and production (Khan *et al*., 2009). Total area of cultivation is 7,586,600 square ha and the total world production was 8519148 ton (FAO, 2012**).** The basis characteristic of recent table grape production is its adaptation to the requirements of the market aiming to improve grape quality, such as identical cluster size, identical size and shape of the berry, equivalent coloration of all the berries in the cluster and higher resistance to shipping (Dimovska *et al*., 2014).

In order to improve the grape quality and to increase the berry size, plant growth regulators must be applied **(**Nampila, 2010). Among the plant growth regulators is gibberellic acid (GA_3), it is extensively used to increase the berry size of seeded and seedless cultivars (Korkutal *et al*., 2007; Dimovska *et al*., 2011). GA_3 is used to promote cell division, stimulate the earlier flowering, and increase the size and yield of berries and clusters. The impact of GA_3 depends on variety, concentration and time of application (Khan, 2009; Dimovska *et al.,* 2006). In general, GA_3 increases grape berries mass when the vine is treated at 1-2 weeks before blooming and return after blooming and before verasion stage (Okamoto and Miura, 2005; Marzouk and Kassem, 2002). Casanova, *et al*. (2009) studied the effect of GA_3 application at 80 ppm at fruit set and 7, 14 and 21 days after fruit set on the Emperatriz seedless grape. They showed that 80 ppm GA_3 increased commercial berry weight by 50% - 90%, reaching similar size to that of 'Aledo' seeded grape, used as comparison. Khan *et al.* (2009) sprayed Flame seedless grapes at bloom and fruit set with GA_3, at concentration of 15, 20 and 25 ppm. For each

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Received on 30/8/2015 and Accepted for Publication on 20/3/2016.

treatment, GA_3 was applied twice with the first spray at 80% blooming and second spray a week later just at fruit set. Average cluster and berry weight of sprayed vines increased significantly over the non-sprayed vines and the largest cluster weight and maximum berry weight, width, length and TSS was found in the treatment with highest concentration of GA_3. Dimovska *et al*. (1014) studied the effect of spraying grapevine cv. Flame seedless with GA_3 at three concentrations including 5, 10 and 20 ppm during three different periods of the vine growing: before blooming, after blooming and before veraison. It was noticed that the concentration of GA_3 had an influence on the characteristics of the berries in the grape growing periods tested. The addition of gibberellic acid at the concentration of 20 ppm increased the weight of the cluster and berry, and increased the transportability of the berries.

Zark is one of most common local cultivar grown in Duhok governorate. The objective of this experiment was to study the effect of GA_3 concentration and frequency on yield and quality of grapes.

MATERIALS AND METHODS

This study was conducted during 2012 growing season on 'Zark' grape. The vines were selected to be as uniform as possible in vigor and grown in a private vineyard located at Kamaki village, Duhok governorate. The vines were 11 years old planted in clay soil spaced at 2 × 2.5 meters, the vines were trained of head training system. Winter pruning was done at the second week of March. Vine load was 20 buds (4 fruiting cane × 6 buds plus 4 replacement spurs × 2 buds).

This experiment included two factors, the first was GA_3 concentration (0, 10, 20 and 30 ppm) and the second was its frequency. It was applied single spray (two weeks before blooming), double (at the same previous date and just after fruit set), or triple (at the same two previous dates and month later). The GA_3 formula used was super Gib (GA_3 tablet) from Alibaba.com. A detergent powder (Tide) as wetting agent at (1-2 $g.L^{-1}$) was added to all the spraying solution including control treatment. The vines were sprayed with GA_3 solutions till run off (1L/vine). The traditional horticultural practices (winter pruning, irrigation, weed control …etc.) were applied as usual. Potential effects of GA_3 concentration and frequency were evaluated in terms of the change in berry set percentage, yield and berries quality. A randomized complete block design with two factors was followed in the experiment. Every treatment consisted of one vine per replicate with three replications, so the number of vines used was 36 vines. All results were analyzed statistically by using SAS programs (2003). Duncan's multiple range test (DMRT) at 5% level of portability was used to compare the treatments means according to Al-Rawi and Kalafalla (2000).

RESULTS AND DISCUSSION:

1. Yield and its components:

Data in table 1 clearly show that increasing number of gibberellic acid (GA_3) sprays significantly increased yield per vine in term of number of clusters per vine, cluster weight and number of berries per cluster. Best values of number of clusters, clusters weight, yield per vine and numbers of berries per cluster were resulted from spraying GA_3 three times. The same table, also, shows that GA_3 concentration significantly increased yield and its components. The maximum yield and its components were obtained from spraying GA_3 at 30 ppm compared to the lowest values from control treatment.

For the interaction between number of sprays and concentration of GA_3, the interaction between triple sprays and highest GA_3 concentration (30ppm) seemed to be more influential in increasing yield properties since it gives the highest values for yield and its components when compared with untreated one.

Results presented in table (1) indicates that high

concentrations of gibberellic acid applied triple significantly increased yield represented in the number of clusters per vine, weight of the cluster and number of berries per cluster, thus improving the grape quantity. These responses has been attributed to GA_3 role in increasing the size and enlargement of plant cells, through its role in increasing plasticity and flexibility of the cell walls and increasing the expansion (Adams et al., 1975; Eman *et al*., 2007 AL-Djaili and Rasheed, 2010). This may be due to an act of auxin-induced from spraying gibberellins which has a role in cell growth and its importance in stimulating and modulating gene cloning processes and translation processes then stimulates the RNA build. On the other hand, the auxin induced by gibberellins is important in stimulating the plasticity of cell walls through break the walls of cellular links, (loosening) and rearrangement of it in new locations under effect of turgor pressure which contributes to an increase in cell division and elongation as well. Malladi and Burns, (2007) mentioned that gibberellins has a role in cell division and improving water absorption and thus increasing cell size by increasing its protoplasm content reflected in increasing the surface of the plant.

Table 1: Effect of GA_3 concentration and frequency on yield and its components of ' Zark' grape.

Treatment		No. of clusters	Cluster weight (g)	No. of berries/ cluster	Yield (kg/vine)
GA_3 frequency	Single	14.83 b	342.92 c	88.08 b	5.149 c
	Double	17.23 a	404.91 b	92.88 a	7.045 b
	Triple	18.36 a	473.17 a	93.89 a	8.757 a
GA_3 conc.	0	14.09 b	340.67 c	83.14 d	4.84 c
	10	16.66 ab	396.28 b	88.51 c	6.68 b
(ppm)	20	18.02 a	436.62 a	93.51 b	7.94 ab
	30	18.47 a	454.18 a	101.32 a	8.48 a
Single	0	12.54 c	273.21 h	81.09 f	3.42 d
	10	14.70 abc	320.99 gh	85.82 ef	4.71 cd
	20	15.89 abc	379.28 ef	90.49 c-e	6.01 bc
	30	16.20 abc	398.00 de	94.94 b-d	6.45 bc
Double	0	13.92 bc	343.21 fg	87.51 d-f	4.78 cd
	10	16.67 abc	412.07 cde	89.56 c-e	6.80 bc
	20	18.94 ab	425.22 cde	92.60 c-e	8.06 ab
	30	19.40 ab	439.00 cd	101.86 ab	8.54 ab
Triple	0	15.81 abc	405.59 cde	80.81 f	6.31 bc
	10	18.62 ab	455.76 bc	90.16 c-e	8.53 ab
	20	19.23 ab	505.35 ab	97.43 bc	9.74 a
	30	19.80 a	525.53 a	107.18 a	10.45 a

Mean in each column followed by the same letters are not significantly different at P≤ 0.05 according to Duncan's multiple range test.

2. Physical properties of berries:

It's clear from data in table 2 that GA_3 frequency had a significant effect on size of 100 berries, juice percentage and juice density. The maximum values (316.95 cm^3, 69.28% and 1.146 g/ cm^3), respectively, were resulted when the grapevine sprayed three times per season, whereas weight of 100 berries was not affected significantly by number of sprays. Moreover, increasing concentration of GA_3 significantly increased weight and size of 100 berries, juice percentage and juice density. The best values (366.18g, 334.10 cm^3, 71.18 % and 1.217 g/ cm^3), respectively, were obtained with highest concentration of GA_3 (30 ppm) compared to the lowest values (296.20g, 286.29cm^3, 58.01% and 1.068 g/ cm^3) resulted from untreated vines.

Table 2: Effect of GA_3 concentrations and frequency on berries quality of 'Zark' grape.

Treatment		Wt. of 100 berries (g)	Size of 100 berries (cm^3)	Juice %	Juice density (OD)
GA_3 frequency	Single	318.16 a	285.60 b	58.27 c	1.089 b
	Double	323.25 a	317.99 a	64.49 b	1.123 a
	Triple	332.30 a	316.95 a	69.28 a	1.146 a
GA_3 conc. (ppm)	0	296.20 c	286.29 b	58.01 c	1.068 c
	10	303.02 c	303.26 b	62.14 bc	1.079 bc
	20	332.89 b	303.73 b	64.71 b	1.114 b
	30	366.18 a	334.10 a	71.18 a	1.217 a
Single	0	279.97 d	264.20 c	50.64 g	1.052 e
	10	297.03 cd	282.17 bc	56.41 fg	1.058 e
	20	331.26 a-d	283.83 bc	60.01 def	1.082 de
	30	364.39 ab	312.22 abc	66.01 b-e	1.165 bc
Double	0	299.80 cd	295.05 bc	59.31 ef	1.070 e
	10	296.62 cd	301.31 abc	62.15 c-f	1.079 de
	20	331.71 a-d	321.71 ab	65.00 b-e	1.116 cde
	30	364.88 ab	353.88 a	71.50 ab	1.227 ab
Triple	0	308.84 cd	299.63 abc	64.08 b-e	1.083 de
	10	315.41 bcd	326.32 ab	67.87 abc	1.099 cde
	20	335.70 abc	305.64 abc	69.12 abc	1.144 ab
	30	369.27 a	336.21 ab	76.03 a	1.259 a

Mean in each column followed by the same letters are not significantly different at $P \leq 0.05$ according to Duncan's multiple range test.

Concerning the interaction between GA_3 concentration and frequency, the highest values of weight of 100 berries, juice% and juice density (369.27g, 76.03% and 1.259 g/ cm^3) respectively, were resulted from the overlapping of spraying 30 ppm GA_3 with triple sprays, while the highest size of 100 berries (353.88 cm^3) was resulted from the overlapping of spraying GA_3 twice at 30 ppm. The lowest values of

weight and size of 100 berries, juice percentage and juice density (279.97g, 264.20 cm^3, 50.64% and 1.052 g/cm^3), respectively, were obtained with control treatment.

The increased berry weight, length and width of the grape 'Zark' were significant when highest concentration of GA_3 was applied, compared to the control. This increase was observed in both double and triple treatments; this influence may be due to an improvement in the total sugars content (Table 3), which, in turn, increases total water content in berries measured as sugar uptake, and, thus, increases berry weight (Zhenming *et al*., 2008). Besides, sugars bear osmotic driving force for cellular expansion (Stadler *et al*., 1999) and modulation of gene expression (Koch, 1996) through signaling mechanisms **(**Lalonde *et al*., 1999**).** The stimulation of growth aspects in response to increasing number of GA_3 application might be ascribed to the positive action of GA_3 on enhancing the biosynthesis of proteins, natural hormone and cell division and elongation (Pérez *et al*., 2000; Casanova *et al.,* 2009), and can be, also, attributed to the availability of GA_3 in more than one stage of growth and development of berry (Hrazdina *et al*., 1984; Possner and Kliever, 1985).

3- Chemical quality of berries:

As can be seen from table 3, both GA_3 concentration and number of sprays had significant effects on total soluble solids, total sugar and total acidity percentage, since the maximum values (20.10%, 22.22 % and 0.385 %) and (20.52%, 23.52 % and 0.357 %) were resulted from spraying GA_3 triple and 30 ppm, respectively. Total phenols percentage was significantly affected only by GA_3 frequency, since the highest total phenols percentage (1.487) was resulted from single spray. The interaction between frequency and GA_3 concentration had significant effect on the chemical quality of berries as the highest TSS and total sugar (22.03% and 25.37 %), respectively, were obtained with the interaction of spraying 30 ppm GA_3 + three times, compared to the lowest values (13.22% and 13.52 %), respectively, obtained with control. The maximum total acidity and total phenols percentage (0.962 % and 1.577 %) were obtained from control compared to the minimum values (0.317 % and 1.189 %), respectively, obtained from the interaction between spraying GA_3 triple and the highest concentration.

Table 3: Effect of GA_3 concentration and frequency on chemical quality of 'Zark' grape berries.

Treatment		TSS (%)	Total sugars (%)	Total acidity (%)	Total phenols (%)
GA_3 frequency	Single	16.53 c	18.51 c	0.544 a	1.487 a
	Double	18.75 b	20.60 b	0.410 b	1.397 ab
	Triple	20.10 a	22.22 a	0.385 b	1.298 b
GA_3 (ppm)	0	15.77 d	16.69 d	0.629 a	1.478 a
	10	18.19 c	19.05 c	0.428 b	1.430 a
	20	19.36 b	22.51 b	0.371 c	1.349 a
	30	20.52 a	23.52 a	0.357 c	1.320 a
Single	0	13.22 g	13.52 j	0.962 a	1.577 a
	10	16.37 ef	17.99 hi	0.442 b	1.515 a

	20	17.75 de	20.78 ef	0.383 bcd	1.451 ab
	30	18.77 cd	21.77 de	0.388 bcd	1.406 ab
Double	0	15.85 f	17.27 i	0.467 b	1.478 ab
	10	18.63 cd	19.09 gh	0.425 bcd	1.413 ab
	20	19.77 bc	22.58 cd	0.380 bcd	1.331 ab
	30	20.77 ab	23.43 bc	0.367 bcd	1.366 ab
Triple	0	18.23 cd	19.26 gh	0.458 bc	1.377 ab
	10	19.56 bc	20.07 fg	0.417 bcd	1.363 ab
	20	20.56 ab	24.18 ab	0.350 cd	1.265 ab
	30	22.03 a	25.37 a	0.317 d	1.189 b

Mean in each column followed by the same letters are not significantly different at P≤ 0.05 according to Duncan's multiple range test.

Like TSS, the flavor and taste of any fruit is largely dependent on the total sugar content of the fruit. GA_3 applied three times per season especially the last application (month after fruit set) increased absolute sugars uptake as suggested by Pérez *et al.* (2000) and Göktürk and Harmankaya (2005) then caused an increase in other properties of grape. This increase can be attributed to increase in concentration of volatile components in fruits along with hydrolysis of starchy compounds towards maturity (Khan *et al*., 2009). These hydrolytic changes usually lead to formation of sugars. The extent of these hydrolytic changes might have increased with GA_3 application. Moreover, the organic acids present in fruits are translocated into sugars towards maturity and this translocation is made faster with GA_3 application (Rachna and Singh, 2013).

The reduction in titratable acidity observed seems to be attributed to the conversion of the organic acids to sugar during fruit ripening by applying plant growth regulators (Abu-Zahra, 2010). The decrease in acidity towards ripening may be attributed to faster movement of potassium into fruits with GA_3 application which in turn increased the membrane permeability of cells allowing respiration of stored acids within the cells and formation of complex compounds of malic acid (Kliewer, 1977) and reduced ability of fruits to synthesize organic acids towards maturity (Kale, *et al.,* 2000).

CONCLUSION

The outcomes of this study suggested that high concentration of GA_3 and increasing number of sprays significantly increased most studied traits, since increasing concentration and number of sprays tended to increase yield per vine in terms of number of clusters, cluster weight and number of berries per cluster, size of 100 berries, juice percentage and density, TSS, total sugars and decrease juice acidity and total phenols, It is recommend to study the use of concentrations higher than the concentrations used in the current study and more than three sprays to test the response of this local cultivar of grape to GA_3 as well as studying its impact on the other local cultivars in this region.

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تأثير تركيز وتكرار الرش بحمض الجبريليك على إنتاج ونوعية العنب صنف زرك

شوكت الأتروشي*

ملخص

أجريت هذه الدراسة في مزرعة عنب خاصة تقع في قرية كمكى بمحافظة دهوك، اقليم كردستان، العراق، خلال موسم الزراعة 2012 لدراسة تأثير أربعة تراكيز من حمض الجبريليك GA_3 (0، 10 و 20 و 30 جزء في المليون) وعدد الرشاشات، رشة واحدة (أسبوعين قبل التزهير) ورشتين (في نفس التاريخ السابق وبعد عقد الحبات) و ثلاث رشات (في نفس التاريخين السابقين وبعد شهر) على انتاج ونوعية شجيرات العنب صنف زرك. أشارت النتائج إلى أن كلا من التركيز وعدد الرشات أحدث زيادة ملحوظة في معظم الصفات المدروسة ، حيث أدت زيادة التركيز وعدد الرشات إلى زيادة حاصل الشجيرات متمثلة في عدد العناقيد ووزن العنقود وعدد الحبات في العنقود، بالإضافة إلى زيادة حجم 100 حبة ونسبة كثافة العصير ونسبة المواد الصلبة الذائبة والسكريات الكلية، كما خفضت نفس المعاملة نسبة الحموضة الكلية والفينولات الكلية في عصير الحبات معنويا. بينما تأثر وزن 100 حبة معنويا فقط بزيادة عدد الرشات. تفوق التداخل بين التركيز 30 جزء في المليون والرش ثلاث مرات معنويا في غالبية الصفات التي تم دراستها عدا حجم 100 حبة والحموضة الكلية والفينولات الكلية.

الكلمات الدالة: العنب، حمض الجبريليك، تركيز،عدد مرات الرش، الإنتاج، النوعية.

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تاريخ استلام البحث 2015/8/30 وتاريخ قبوله 2016/3/20.