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Cluster and Berry Characteristics of Grapevine (*Vitis vinifera* L.) as Influenced by Thinning Agents and Gibberrelic Acid Applications

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Abstract
Some cultivars of grapevine have very compact cluster which adversely affect its quality and marketability. 'Yaghouti' is a commercial early table grape cultivar that has very compact clusters. The present study was conducted to assess the effects of mechanical and chemical thinning as well as GA_3 application on cluster morphology and berry size of grapevine cv. 'Yaghouti'. Treatments were chemical thinning agents including: NAA (7.5 and 15 mg/L), Ethephon (75 and 150 mg/L), Sevin (750 and 1500 mg/L) and mechanical thinning by a comb (comb thinning), applied a week after fruit set and unthinned clusters as control with 3 replications, 10 days after thinning, clusters were immersed in GA_3 solution at 60 mg/L. Results indicated that berry numbers were reduced in all thinning treatments. Length, width and weight of berries increased significantly when treated with hand or chemical thinning. GA_3 alone and Sevin at 750 mg/L in combination with GA_3 treatment improved yield and the quality of berries. Total phenolics compounds, TSS and berries colour were improved in all thinning treatments. In general, application of Sevin at 750 mg/L combined with GA_3 and hand thinning along with GA_3 are proposed to improve quality of grapevine berries.

Keywords: Ethephon, comb thinning, Sevin , compact bunch.

Introduction

'Yaghouti' grapevine (*Vitis vinifera* L.) is economically and socially important for the production of early table grape and grown in different regions especially in South of Iran. It is used as seedless table grape and juice. It has become favourable cultivar among growers because of its remunerative prices and high profitability. Also this cultivar has low chilling requirement and is suitable for growing in subtropical climates with mild winter and limited chilling hours. Table grapes produce good yield when having attractive appearance, good eating properties, large and consistently sized berries, sturdy rachis and strong attachment of the berry to the rachis. Ideally, grapes for fresh consumption should also be resistant to both injuries caused by handling and postharvest diseases (Salehi et al., 2013).

Some cultivars of grapevine bear very compact bunch, which has an adverse effect on its quality and marketing. 'Yaghouti' is a commercial cultivar of grapevine in Iran that has very compact bunches with small berry size. Chemical thinning is a common and

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effective practice in perennial fruit crops to reduce the amount of flowers and fruitlets. Chemical thinning response depends on many factors such as, plant species, type and concentration of the chemical thinning agents, environmental factors during and after the chemical application, internal factors and the timing of application (Stoper et al., 2007a,b).

Exogenous growth regulators and hand thinning were applied to improve the cluster morphology, berry size and facilitate the marketing of table seedless grapes (Creasy and Creasy, 2009). The effect of various thinning agents was investigated in different researches including seedless grapes (Creasy and Creasy, 2009; Taleb, 2010), Pistachio (Rahemi and Ramezanian, 2007), Peach (Vego et al., 2010; Schuppet et al., 2008), Apricot (Son, 2004), Apple (Stoper et al., 2007a, b), (Szot, 2010; Marini, 2004; Robinson and Lopez, 2010), Blueberries (Frank et al., 2005), and Pear (Wertheim, 2000; Dennis, 2000).

Hand thinning applied to the apricot increases fruit weight up to 50 percent as well as TSS of the fruits when it is carried out four weeks after full bloom (Levent, 2010). Szot (2010) reported that hand thinning on apple cv. Sampion after full bloom improved fruit quality and increased commercial fruits. Reducing berry number in bunch of Thompson Seedless grape enhanced ripening, improved TSS, phenolic compounds, weight and size of berries when compared with untreated control clusters on the same vine (Wood, 1977; Looney, 1981; Looney and Wood, 1977; Singh and Chundawat, 1980). Cluster thinning in 'BRS Vitoria' (a new black seedless grape) when berries are between 7 and 18 mm in diameter is efficient for reducing cluster compactness and improve berry size quality (Roberto et al., 2015). Similarly, for 'Black Star' grapes, brushing thinning at the pre-flowering stage, as practiced for 'Itália' grapes, appears to be the preferred method (Roberto et al., 2017). Mawdsley et al. (2018) reported that timing of cluster thinning across two growing season had no positive effects on Pinot noir grapes and wines. Manual cluster thinning reduced significantly grape production by diminishing the number of cluster per vine however increased berry size and sugar as well as anthocyanin contents (Silver, 2018).

Spraying Sevin at the rate of 0.1 and 0.2 percent on grapevine cv. Perlette significantly thinned berries when compared with untreated control ones (Makhija et al., 1988). In blueberry, Sevin at 400 mg/L, 10 days after petal fall effectively thinned the fruitlets and increased fruit diameter (Frank et al., 2005). Also, Sevin application after petal fall in apple cv. Honey Crisp thinned the fruits and improved fruit quality (Robinson and Lopez, 2010). Naito et al. (1985) reported that Sevin at the rate of 500 mg/L significantly increases size and weight of clusters and improves berry ripening and quality.

NAA at concentration of 15 mg/L on blueberry, 10 and 20 days after petal fall causes fruit thinning and increases fruit size (Frank et al., 2005). In pistachio, NAA at 250 mg/L reduces the number of fruits and increases nut diameter and weight (Rahemi and Ramezanian, 2007). In apple, NAA causes fruit thinning and increases the diameter of retained fruits (Stoper et al., 2007b).

Foliar spray of ethephon at the rate of 0.6 percent on peach and nectarine at full bloom stage effectively decreases the number of fruits and increases the size of retained fruits (Vego et et al., 2010). Ethephon application at concentration of 100 and 200 mg/L in pistachio trees reduces the number of fruits and increases the nut weights (Rahemi and Ramezanian, 2007).

Gibberellic acid application (50 mg/L) after full bloom on Thompson Seedless grapevine improves berry size, weight, and cluster morphology as well as its qualitative characteristics (Lavin, 1982; Gil and Escobar, 1979; Taleb, 2010).

The studies on the effect of thinning agents on grapevine cluster morphology are limited. Although 'Yaghouti' grapevine is an important commercial seedless and

early ripening cultivar, but it has a very compact clusters with very small berry size. To date, the effect of thinning agents on this cultivar was not comprehensively investigated. Therefore, this study aimed to evaluate the effect of different concentrations of chemical thinning agents, comb thinning which followed by application of gibberellic acid (GA_3) on cluster morphology, increasing berry size and yield of 'Yaghouti' grapevine.

Materials and methods

Present study was carried out in a commercial vineyard in Kavar region, Fars province (altitude: 1550 m), on 5 years old head- trained 'Yaghouti' grapevines, cultured with 2×3 m distance, during two consecutive years. To reduce the number of berries, thinning treatments were applied on the leaves (three litres for each vine) a week after fruit set. The chemical thinning agents included: ethephon at concentrations of 75 and 150 mg/L, NAA at concentrations of 7.5 and 15 mg/L, Sevin at concentrations of 750 and 1500 mg/L and mechanical thinning by a comb (comb thinning), then ten days after application of thinning treatments, the clusters were immersed in GA_3 at 60 mg/L solution for ten seconds.

At the harvest time (TSS ≥ 16), four ripened clusters from each vine (replicate) were harvested randomly and quantitative characteristics including cluster weight, cluster diameter, cluster length, number of berries in cluster, berry weight, berry length, berry diameter and L/D of berry and qualitative characteristics (TSS, total acids, polyphenolic compounds, total anthocyanin content (TAC), antioxidant activity (AA), and TSS/TA ratio) were determined.

The numbera of berries per cluster at the harvest time were counted. Hundred berries from each replication (four clusters) were taken for the measurements of berry traits. The percentage of total soluble solids (TSS %) was measured by a hand Refractometer (Arma company), total acidity (TA, %) was determined by titrating the berry juice. The weight of harvested clusters was also recorded.

Total phenolic content (TPC) of grape juice (GJ) was determined spectrophotometrically using the Folin Ciocalteu reagent (Mustafa *et al*., 2009). The absorbance versus prepared blank was read at 760 nm until it reached steady state. The same procedure was applied for six standard solutions of catechin (50–300 mg/100 ml). Final results were expressed as mg catechin equivalent per 100 ml of GJ.

Total anthocyanin content (TA) of the grapes was determined using the pH-differential method described by Wrolstad (1976). Absorbance was measured using a Hitachi U-2000 spectrophotometer at 520 and 700 nm (Carreno et al., 1995).

The absorbance values of the diluted samples (A) were calculated as follows:

$$A= (A_{520nm}-A_{700nm})\ pH_1 - (A_{520nm}-A_{700nm})\ pH_{4.5}$$

The total anthocyanin (TA) pigment (mg kg^{-1}) was calculated based on the following equation:

$$TA= \frac{A \times MW \times DF \times 10\ \hat{}3}{\varepsilon \times l}$$

DF= dilution factor established in D; l = path length in cm; e= 26 900 molar extinction coefficient, in L ´mol^{-1}´ cm^{-1}, for cyd-3-glu; and 10^3 = factor for conversion from g to mg.

The result, considered as the total anthocyanins content, was calculated as milligram of malvidin-3-O-glu per 1000 g fruit by using a molar absorptivity (ε) of 28,000 and a molecular weight (MW) of 493.5 according to Wrolstad (1976).

The total antioxidant activity (AA) of the grape extracts was evaluated by free radical 2, 2-dipheynl-1-picrylhydrazyl (DPPH) method (Moon and Terao, 1998; AOAC, 2005). Absorbance was measured spectrophotometrically at 517 nm by a UV-visspectrophotometer. The percentage of reduction of DPPH was calculated according to the following equation:

$$\text{Antioxidant activity (\%)} = [1 - \frac{\text{Asample(517nm)}}{\text{Acontrol(517nm)}}] \times 100$$

Statistical analysis

The research was done as a factorial experiment in a completely randomized block design with 16 (8 x 2) treatments and three replications (in all 48 vines). Data were analyzed by SAS 9.1.3 and the means were compared using LSD test at 5% probability.

Results

Results of interaction of thinning agents and GA_3 showed that Sevin at 1500 mg/L concentration along with GA_3 increased cluster diameter about 6.66% in comparison with unthinned control clusters (Table 1). The highest cluster length (16.4 cm) obtained when 750 mg/L of Sevin solution in combination with GA_3 was applied. Berry weight was increased (1.5 folds heavier than the control berries) was obtained from vines mechanically thinned in presence of GA_3 (Table 2, Fig. 1). The highest cluster weight (428.1 g) was obtained from vines treated with 750 mg/L of Sevin solution combined with GA_3 while vines treated with 15 mg/L of NAA without GA_3 application produced 235.5g weight of cluster.

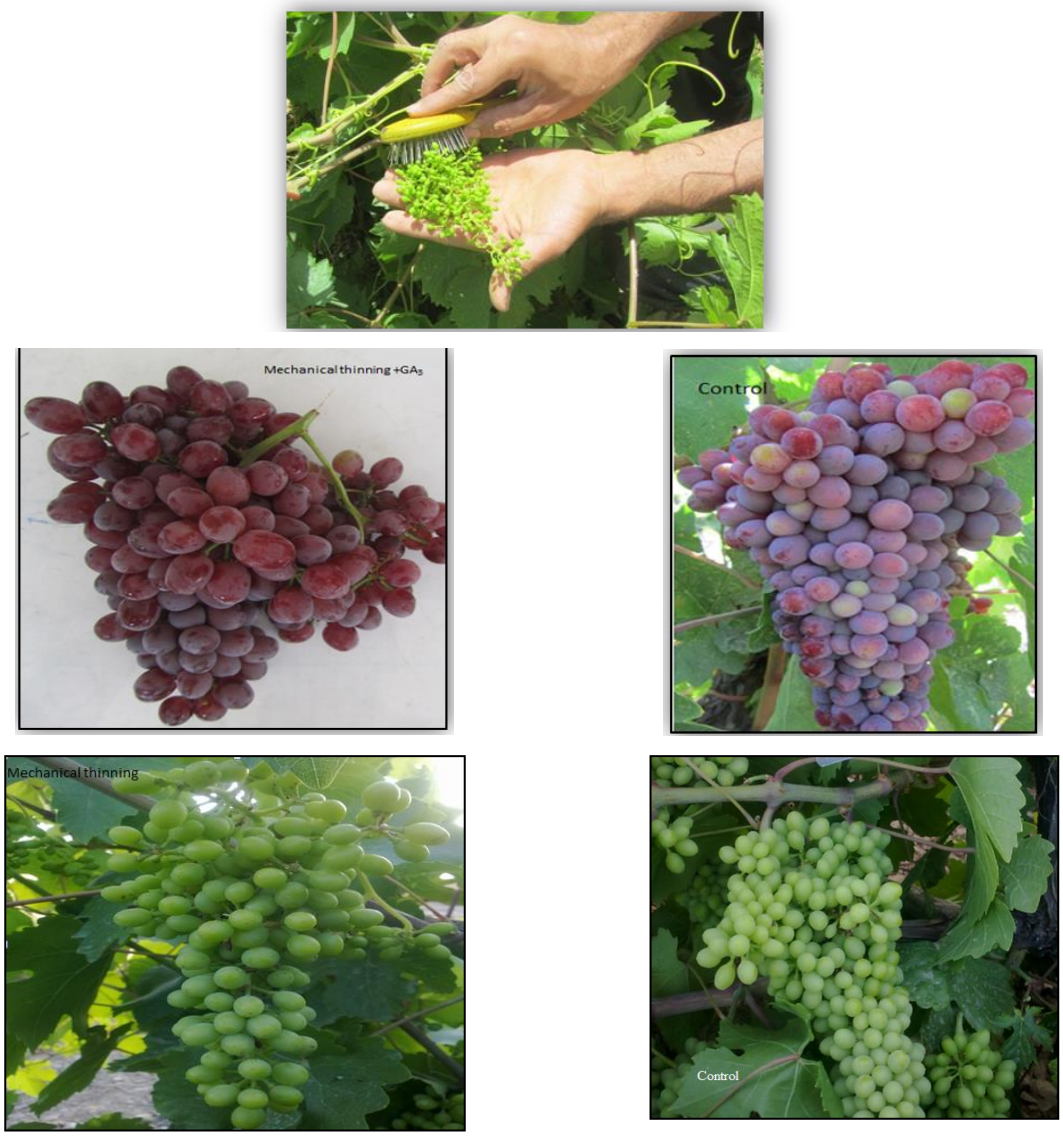

Fig. 1. Effect of comb (mechanical) thinning and GA_3 application on 'Yaghouti' grape.

Table 1. Interaction effect of chemical and hand thinning and gibberellic acid on cluster diameter, length and weight of 'Yaghouti' grapevine cultivar.

Treatments	cluster diameter (cm)			cluster length (cm)			cluster weight (g)		
	GA_3 (mg/L)			GA_3 (mg/L)			GA_3 (mg/L)		
	0	60	Mean	0	60	Mean	0	60	Mean
Control	26.7bcd†	28.3a-c	27.5AB	15.1bc	14.8bc	15B	318b-d	302b-d	310.5A
Hand thinning	26.9a-d	30.4a	28.6A	15.7b	16.9ab	16A	304.82b-d	318.4b-d	311.6A
NAA 7.5 mg/L	27.4a-d	27.2a-d	27.3AB	15.6b	15.5a-c	15.5AB	274b-d	299.2b-d	286.7AB
NAA 15 mg/L	25.6cd	26.2b-d	25.9B	15.2bc	16.3ab	15.7 AB	235.5d	251d	243.4B
Ethephon 75 mg/L	24.5d	27.4a-d	25.9B	15bc	15.8ab	15.4 AB	269.5cd	339.3bc	302.4AB
Ethephon 150 mg/L	25.5cd	27.9a-d	26.7AB	15.2bc	14.8bc	15B	316bcd	285.5b-d	300.8AB
Sevin 750 mg/L	25.1cd	29.3ab	27.2AB	13.6c	17.6a	15.6 AB	245.3d	428.1a	336.7A
Sevin 1500 mg/L	27.4a-d	30.5a	29A	15.6b	16.4ab	16 AB	303.4b-d	361.8ab	332.6A
Mean	26.1B	28.4A		15.1B	16A		282.8B	323.1A	

†Means within columns and rows for each trait followed by the same letters are not significantly different at $P \leq 0.05$ using LSD test.

Table 2. Interaction effect of chemical and hand thinning and gibberellic acid on berry diameter, length and weight of 'Yaghouti' grapevine cultivar.

Treatments	Berry diameter (cm)			Berry length (cm)			Berry weight (g)		
	GA_3(mg/L)			GA_3 (mg/L)			GA_3 (mg/L)		
	0	60	Mean	0	60	Mean	0	60	Mean
Control	1.04f†	1.14c-e	1.09C	1.14g	1.25d-f	1.19D	2.77f	3.22ef	2.9D
Hand thinning	1.17a-e	1.26a	1.21A	1.27c-e	1.41a	1.34A	3.5be	3.93a	3.86A
NAA 7.5 mg/L	1.13d-f	1.25a	1.19AB	1.2e-g	1.37ab	1.28A-C	3.06d-f	3.92ab	3.51AB
NAA 15 mg/L	1.2a-d	1.24ab	1.22A	1.27c-e	1.36a-c	1.31AB	3.45b-e	3.51ab	3.68AB
Ethephon 75 mg/L	1.1ef	1.18a-e	1.14BC	1.17fg	1.28b-e	1.23CD	2.77f	3.58b-e	3.11BC
Ethephon 150 mg/L	1.16b-e	1.23a-c	1.19 AB	1.25d-f	1.37ab	1.31AB	3.06d-f	3.65b-d	3.32BC
Sevin 750 mg/L	1.15b-e	1.12d-f	1.13 AB	1.21e-g	1.32a-d	1.26BC	3.01ef	3.66bc	3.33BC
Sevin 1500 mg/L	1.16b-d	1.21a-d	1.18 AB	1.28b-e	1.36a-c	1.23CD	3.23c-f	3.69bc	3.43BC
Mean	1.14B	1.2A		1.22B	1.34A		3.1B	3.64A	

†Means within columns and rows for each trait followed by the same letters are not significantly different at $P \leq 0.05$ using LSD test.

Results of interaction effects of thinning agents and GA_3 on berry diameter indicated that the greatest berry diameter (1.26 cm) obtained when clusters were mechanically thinned in combination with GA_3 treatment. Unthinned control clusters without GA_3 treatment has berries with 1.04 cm of diameter; however other treatments had significant differences with control in the presence of GA_3 treatment (Table 2). The highest berry length (1.34 cm) was obtained in mechanically thinned clusters in the presence of GA_3, which caused 18% increase in the length of berry in comparison to berries of unthinned control clusters (Table 2).

Sevin at 1500 mg/L concentration in the absence of GA_3 decreased the number of berries up to 53.5% in comparison with unthinned clusters, from 327.6 to 152.3, respectively (Table 3). Yield per vine (6735 g) obtained when vines treated with 750 mg/L of Sevin solution along with GA_3 treatment and the lowest yield (4710 g) obtained from vines treated with 15 mg/L of NAA in the absence of GA_3 treatment. Yield increased significantly when GA_3 was applied (Table 3). Berry length to diameter ratio increased significantly in the presence of GA_3 in comparison with absence of this treatment (Table 3).

Berries treated with 7.5 mg/L of NAA without GA_3 application had the highest TSS (18.6%) level which was 26.53% more than those of in control berries (14.7%). TSS was significantly higher in all thinning treatments when compared to the TSS of the control (Table 4). All treatments had no significant effect on total acid of berries (Table 4). The highest TSS/TA ratio (27.59) was obtained from mechanically thinned clusters in the presence of GA_3 and the lowest of TSS/TA (19.95) obtained in berries thinned with 750 mg/L of Sevin solution and GA3 application (Table 4).

Data in Table 5 show that the effect of thinning agents and GA_3 application on anthocyanin, total phenolic compounds and antioxidant activity was not significant.

Table 3. Interaction effect of chemical and mechanical thinners and gibberellic acid on number of berry, L/D of berry and yield of 'Yaghouti' grapevine cultivar.

Treatments	Number of berry			L/D of berry (cm)			Yield (g/vine)		
	GA_3(mg/L)			GA_3(mg/L)			GA_3(mg/L)		
	0	60	Mean	0	60	Mean	0	60	Mean
Control	327.6a†	318.3ab	323A	1.09bc	1.09bc	1.09AB	6360b-d	6041.7b-d	6200.8A
Hand thinning	203.6c-e	205cde	204.3BC	1.08bc	1.12ab	1.1AB	6096.7b-d	6368.3b-d	6232.5A
NAA 7.5 mg/L	227b-e	231.3b-e	229.1BC	1.05c	1.09bc	1.07B	5483.3b-d	5985b-d	5734.1AB
NAA 15 mg/L	281.6a-c	233.6b-c	257.6B	1.05c	1.09bc	1.07B	4710b	5020d	4865B
Ethephon 75 mg/L	224.3c-e	197.3c-e	210.8BC	1.06c	1.09bc	1.07B	5310cd	6786.7bc	6048.3AB
Ethephon 150 mg/L	198c-e	182de	190C	1.07bc	1.11b	1.09AB	6321.7b-d	5710b-d	6015.8AB
Sevin 750 mg/L	275a-c	214.6c-e	244.4BC	1.05c	1.17a	1.11A	4906.7d	8563.3a	6735A
Sevin 1500 mg/L	152.3e	258.3a-d	205.3BC	1.1bc	1.12ab	1.11A	6068.3b-d	7236.7ab	6652.5A
Mean	236.2A	230A		1B	1.11A		5657.1B	6464A	

†Means within columns and rows for each trait followed by the same letters are not significantly different at $P \leq 0.05$ using LSD test.

Table 4. Interaction effect of chemical and mechanical thinners and gibberellic acid on TSS, TA and TSS/TA of 'Yaghouti' grapevine cultivar.

Treatments	TSS (%)			TA (g acid/100ml)			TSS/TA		
	GA_3(mg/L)			GA_3(mg/L)			GA_3(mg/L)		
	0	60	Mean	0	60	Mean	0	60	Mean
Control	14.7e†	14.8c-e	14.3C	0.69b	0.75b	0.72B	20.19d-f	20.1ef	20.14B
Hand thinning	16.8a-d	17.1a-c	17AB	0.67b	0.58b	0.63B	24.93a-e	30.24a	27.59A
NAA 7.5 mg/L	18.6a	17.6ab	18.1A	0.70b	0.72b	0.63B	26.66a-e	24.65a-e	25.66A
NAA 15 mg/L	17.6ab	18.5a	18A	0.66b	0.69b	0.67B	26.84a-e	26.92a-d	26.88A
Ethephon 75 mg/L	17.5ab	17.6ab	17.5AB	0.70b	0.63b	0.66B	24.96a-e	28.49ab	26.72A
Ethephon 150 mg/L	17.6ab	16b-d	16.8AB	0.70b	0.75b	0.72B	25.19a-e	21.32c-f	23.25AB
Sevin 750 mg/L	15.5be	16.6a-d	16B	1.06a	0.72b	0.89A	16.64f	23.26b-f	19.95B
Sevin 1500 mg/L	17.3ab	14.6de	16BC	0.64b	0.70b	0.67B	27.19a-c	20.89c-f	24.04AB
Mean	16.8A	16.6A		0.73A	0.69B		24.08A	24.48A	

†Means within columns and rows for each trait followed by the same letters are not significantly different at $P \leq 0.05$ using LSD test.

Table 5. Interaction effect of chemical and mechanical thinners and gibberellic acid on total anthocyanin (TAC), total phenol and antioxidant activity (AA) of 'Yaghouti' grapevine cultivar.

Treatments	TAC (mg/L)			Total Phenol(mg/100ml)			AA(%)		
	GA_3(mg/L)			GA_3(mg/L)			GA_3(mg/L)		
	0	60	Mean	0	60	Mean	0	60	Mean
Control	70a†	70.3a	70.2A	0.061a	0.061a	0.061A	47a	48a	47A
Hand thinning	67.47a	72.4a	69.9A	0.064a	0.068a	0.066A	58a	49a	54A
Na 7.5 mg/L	68.5a	76.3a	72.4A	0.060a	0.061a	0.060A	56a	42a	49A
Na 15mg/L	72.7a	69.6a	71.7A	0.061a	0.061a	0.060A	49a	55a	52A
Ethephon 75 mg/L	72.7a	74.8a	73.7A	0.068a	0.065a	0.067A	49a	45a	47A
Ethephon 150 mg/L	73.7a	74.1a	73.9A	0.064a	0.069a	0.066A	47a	46a	47A
Sevin 750 mg/L	67.9b	75.3a	71.6A	0.053a	0.057a	0.055A	49a	44a	46A
Sevin 1500 mg/L	73.6a	70.1a	71.8A	0.065a	0.064a	0.065A	47a	54a	50A
Mean	70.82A	72.9A		0.063A	0.062A		50A	48A	

†Means within columns and rows for each trait followed by the same letters are not significantly different at $P \leq 0.05$ using LSD test.

Discussion

In the present study, the effectiveness of chemical thinning agents and comb thinning in order to make cluster lose and to enlarge the berry size in Yaghouti grape was evaluated. Fruit and flower thinning is a common practice in a wide range of fruit trees and some grape cultivars. The goal of this practice is to guarantee a constant production, protect over producing trees, produce uniform fruit size and high quality fruits in order to have a lucrative agriculture-economy (Davis, 2004).

As it has been mentioned in result section, all thinning treatments decreased the number of berries in the cluster. Sevin at the concentration of 1500 mg/L had the highest influence on reduction of berry numbers when applied in the absence of GA_3, ethphon at 150 mg/L concentration

combined with GA_3 treatment had similar reducing impact. Similar results have been reported by other studies (Levent, 2010; Szot, 2010; Robinson and Lopez, 2010). The reduced yield per vine achieved by cluster thinning has been also reported (Vego et et al., 2010). Cluster weight increased significantly in the presence of GA_3 (Table 1). Similar results have been reported by Creasy and Creasy (2009) and Taleb (2010). The highest berry length (1.34 cm) was obtained from mechanically thinned clusters in the presence of GA_3 (about 18% increase) and the lowest berry length was obtained in control samples (Table 2). These findings are in accordance with those reported in previous studies (Frank et al., 2005; Naito et al., 1985; Son, 2004; Lavin, 1982; Gil and Escobar, 1979; Taleb, 2010).

Sevin blocks the vascular translocation of assimilate to the small fruits, this leads to competition of these fruits with normal and larger fruits as well as with vegetative parts and ultimately results in their abscission (Dennis, 2000). Ethephon is stable and liquid compound under low pH but with a rise in pH it is unstable. Plant cells absorb this compound in liquid form and in neutral pH of cytoplasm, ethephon degrades and produce ethylene, which triggers production of endogenous ethylene and leads to flower and fruit abscission. Ethylene induces callus synthesis, which blocks vascular system, this leads to reduction in water and assimilate translocation which increases water potential of xylem and assimilate restriction results in fruit abscission because of this competition (Ryugo, 1988).

In our study, thinning treatments decreased yield. We applied GA_3 in order to compensate this yield loss; although there were no significant differences between control and thinning treatments for their yields. However, following GA_3 spray yield was increased in thinning treatments such as Sevin at 750 and 1500 mg/L concentration, ethephon at 75 mg/L concentration and comb thinning in comparison with thinned clusters without GA_3 application. In the present study, yield augmentation induced by GA_3, was caused by thinning effect which gave the berries higher space and more nutrient uptake, resulted in higher berries size. GA_3 induced cellular enlargement by loosening of cell wall, this occurs as the result of enzymatic activities which break the hydrogen-bonds in cell wall. Auxin and GA_3 usually act with together to enlarge the cell. Quantity parameters such as berry weight, berry length, yield and cluster weights were directly affected by thinning treatments. In the present study, because of compactness of clusters, thinning alone did not cause enlargement of berries. However, in all thinning treatments which followed by GA_3 application, enlargement of berries and increase in berry size and yield were observed.

Enlargement of berries did not cause increase in cluster diameter and there were no significant differences between treatments and control samples, this was due to reduction in berries number. Decrease in the number of berries did not cause reduction of leaf area (increase in leaf to fruit ratio), which did not weaken the plant while it optimized the plant growth as well (Marini, 2004).

In the present study, although the control treatment showed the highest average yield per vine and productivity in comparison to some thinning treatments, it is important to mention that the berry thinning is an essential operation to enhance the attributes related to appearance, such as compactness and weight of berries because these factors determine the marketability and price of Yaghouti early table grape.

In general, the thinning is a mandatory practice for ‘Yaghouti’ table grapes in order to prevent bunch compactness and to increase berry size. Without this practice, bunches would be highly compacted, which makes the practice of pest control more difficult and decrease the consumer

satisfaction. Productivity of plants thinned by combing is similar to those subjected to berry-cluster thinning.

Conclusion

Since the majority of flowers on cluster set to berries in 'Yaghouti' grapevine, clusters would be very compact and their morphology would be unsuitable. Taken all the result obtained from current study with together, thinning agents reduced the number of berries in cluster resulted in producing loose cluster with more suitable appearance. Application of GA_3 improved the berry size. In general, application of Sevin at 750 mg/L and comb thinning both in combination with GA_3 are proposed to achieve the best quality and marketability in 'Yaghouti' grapevine.

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Conflict of interest

The authors indicate no conflict of interest for this work.

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