BIO Web of Conferences **7**, 01032 (2016) DOI: 10.1051/bioconf/20160701032
39th World Congress of Vine and Wine

Effects of cane girdling on yield, fruit quality and maturation of (*Vitis vinifera L.*) cv. Flame Seedless

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Abstract. This study was carried out to determine the effects of cane girdling on coloration, maturation, yield and some quality characteristics of Vitis vinifera L. cv. Flame Seedless table grape variety. Cane girdling practices were treated at pea-size stage (G2) and veraison period (G1) over two growing seasons, 2013–2014, at the facility of Manisa Viticultural Research Institute in Turkey. Cane girdling was performed on the canes after first shoot was left from the bottom and 4 mm-wide ring of bark was completely removed with a doubleded knife. On the other hand control vines were left untouched. Statistical analyses showed that TSS, berry length, colour parameters, CIRG index and anthocyanin content of Flame Seedless was significantly affected by the cane girdling treatments in both years, 2013 and 2014. In addition it was detected that any effect of girdling treatments cannot be determined statistically significant on total yield, marketable yield, titrable acidity and 50 berry weight. Total and marketable yields of girdled vines had higher value than control vines although they were not statistically significant. Furthermore it was observed 9 and 12 days earliness with G2 treatments compare to the control vines in 2013 and 2014, respectively.

1. Introduction

Turkey is placed on the most suitable temperate zone in terms of viticulture all around the world. More than thousand grape varieties have been grown in overall the country and cultivar richness with history show that Turkey is one of the first grape growing centers [1]. Total fresh grape production, vine planted area and grape yield of Turkey are 4.011.409 ton, 468.792 ha and 855,69 kg/da, respectively [2]. Furthermore Turkey places 5 th and 6 th rank among the world countries in terms of vine planted area and grape production [3].

Because of its high nutritional content, full flavor, occasional and multi usage (Table grapes, raisins, wine, juice for concentrate etc.), grape is becoming more popular [4]. Therefore table grape consumption has increased in all over the world [5]. Today, almost 77 million tonnes of world grape production that is almost 4 million tonnes are yielded in Turkey [3] and this production is characterized as primary table grapes (53%) and as secondary raisin yield (35%) (Turkey Statistical Institute, 2013). The basic characteristic of modern table grape production is its adaptation to the requirements of the market aiming to improve grape quality, such as equal cluster size, uniform shape and berry size, equal coloration of all the berries in the cluster and higher resistance to transportation. Furthermore, an important speciality of the grape is seedlessness and generally seedless varieties are characterized with small berries and require management and some cultural activities for improvement of their size. In addition uniform coloration is one of the most important feature of the table grape production [6].

Different viticultural techniques and treatments are necessary to get better yield and superior quality for table grape production. There are so many factors which affects grape quality directly during the grape growing; such as pruning, crop load, thinning, girdling, topping, pinching and using of plant growth regulators [7]. In other words quality, quantity and nutritoanal value of grape is under the influence of some agricultural practices and techniques.

Girdling is one of the these practices and techniques which consists of removing a small section of phloem (about 4mm in width) from either stem or cane. It has been practiced for many years to provide bigger berries in terms of table grape production or to provide fruit maturity by enhancing berry coloration or accumulation of sugar [7–9]. Also physical characteristics of grapes such as colour, form and shape are so important attributes for consumers [10,11]. Therefore girdling in vineyards is become crucial technique for table grape production.

In most of studies grapes are girdled at berry set to increase berry size or at veraison (berry softening or colour break) to ensure better maturation and colour development. Increment in berry size owing to girdling is result of better carbohydrate nutrition above the girdle because the transport of sugars from leaves to the root system is blocked by girdling treatment [7]. Also changes in the hormonal balance of the grapevine after girdling may cause an increament on berry size [12]. In addition girdling of the grapevine has been reported to improve berry colour and stimulate maturation of grapes [10].

The aim of this research was to examine the effect of cane girdling on the fruit development and the quality

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Table 1. Effects of girdling on some quality parameters in the year 2013.

Treatments	TSS (%)	pH	TA (g/1t)	50 Berry Weight (g)	Berry Width (mm)	Berry Length (mm)	Marketable Yield Ratio (%)	Total Yield (g)
C	18.533b	3,777b	4,03	115,617	13,690b	13,533b	66,823	19571,67
G1	21,400a	3,830ab	4,193	113,853	14,107b	13,417b	83,043	19937,50
G2	21,333a	3,870a	4,193	127,03	15,940a	15,000a	76,213	20960,83
P	**	*			**	**		
LSD	1,292	0,068	ns	ns	1,557	1,353	ns	ns

*G1: Girdling at veraison period, G2: Girdling at pea-sized stage, C: Control, Ns: non-significant, * $p < 0,05$ ** $p < 0,01$.*

of Flame seedless grape variety which grown in Aegean region of Turkey.

2. Materials and methods

The study was carried out in the experimental vineyards of Manisa Viticultural Research Institute (located between the 38°37' North latitudes and 27° 24' East longitudes), during 2013 and 2014 seasons. As a plant material Flame Seedless grape variety was grafted onto 1103 Paulsen rootstock. Grafted vines planted in 2004 with 3 × 3 m row spaces and trained to rational pergola systems. Canopy height of the pergola system was 2.40 m. Grapevines were cane-pruned and left 6 canes of 10/12 buds per vine during the winter pruning.

There were 3 application in the research; G1, G2 and Control. G1-girdling application was performed at the begining of veraison period and G2-girdling application was performed at pea-sized of berries. Also there was no application for Control. Cane girdling was performed on the canes after first shoot was left from the bottom. 4 mm-wide ring of bark was completely removed with a doubleded knife. Control vines were left untouched. Every application consisted of three replicates of 3 vines. When the clusters on the control vines reached to about 18° Bx, harvest was done and all samples were immediately brought to the laboratory for analysis.

2.1. Measured parameters

Yield parameters such as total yield (g) and marketable yield ratio (%) were determined after harvest. In addition 50 berries were sampled from each replication and after sampled berries were weighed, the average berry weight (g) was determined. Also berry width and berry length (mm) was measured by using caliper compass and colour measurements (L, a, b, Chr, Hue) were made by Minolta Co (CR-300). CIRG Index (Colour Index of Red Grapes) was estimated according to the [13]. Berries were squeezed for each replication and the percentage of total soluble solids percentage (TSS %) was measured by the Refractometer. On the other hand juice pH was measured by pH meter and total anthocyanin with phenolic contents were determined according to the [14]. Total titratable acidity percentage (TA %) was measured by titrating the berry juice with 0.1*N*NaOH. The TA% was expressed as grams of tartaric acid per 100 ml of juice [15].

2.2. Statistical analysis

The experimental design was randomized parcels with three replicates. Analysis of variance was implemented to research data by using the SPSS [16] statistical programme on computer, and in order to determine the differences among averages, LSD test was implemented on importance level of 5% and 1%.

3. Results and discussion

Vines are girdled in an attempt to improve fruit setting, maturation, quality and yield parameters [7,17–19]. Girdling practices cut the movement in the phloem and change the hormonal balance [12]. Therefore it leads to an increment of carbohydrates above the girdle [20]. When the TSS and TA values have been examined, effect of girdling treatment on TSS was found statistically significant ($p < 0,01$) in two years while effect of practices on acidity content were not considered statistically important (Table 1 and 2). It is known that that TSS and acidity play an important role in fruit quality improvement [14,18,21–23]. Highest TSS value was observed with G2 treatment statistically in 2014 season (22.0° Bx). Furthermore it was observed 9 and 12 days earliness with G2 treatments compare to the control vines in 2013 and 2014, respectively. According to the TSS values, it was observed that girdling treatments accelerates ripening. Our results are in agreement with the findings of [17,24–28].

As can be seen from the results in Tables 1 and 2, first year the effect of girdling treatment on berry width and berry length was statistically significant ($p < 0,01$). Additionally highest values were obtained with G2 treatments 15,94 mm and 15,00 mm, respectively in the year 2013. It was found non-significant when the berry weight values have been examined but it was observed that higher values were obtained from G2 treatments in both years. These findings are in agreement with previous studies and girdling at berry set has been reported by several investigators to increase in berry size especially in seedless varieties. For example, [24] and [29] reported that girdling of Crimson Seedless at berry set increased berry weight and berry volume [28].

In both years, effects of girdling treatments on total yield and marketable yield ratio was statistically non-significant (Tables 1 and 2). Similar results were obtained by [18] in Turkey. They reported that girdling treatments had non-significant effects on yield of "Trakya İlkeren" table grapes.

Visual factors are very important in determining the quality of table grapes and it is known that coloration is one of the most prominent visual factor [30]. Therefore fruit colour is an important quality attribute in table grapes. As seen in Tables 3 and 4, all colour parameteres are

Table 2. Effects of girdling on some quality parameters in the year 2014.

Treatments	TSS (%)	pH	TA (g/1t)	50 Berry Weight (g)	Berry Width (mm)	Berry Length (mm)	Marketable Yield Ratio (%)	Total Yield (g)
C	18,447b	4,057	3,08	112,623	13,58	13,073b	67,983	26708,33
G1	21,000ab	4,037	2,573	112,513	13,96	14,180ab	83,013	20953,33
G2	22,000a	4	3,02	132,47	14,57	15,000a	75,88	26253,33
P	**					*		
LSD	2,567	ns	ns	ns	ns	1,216	ns	ns

*G1: Girdling at veraison period, G2: Girdling at pea-sized stage, C: Control, Ns: non-significant, * $p < 0,05$ ** $p < 0,01$.*

Table 3. Effects of girdling on colour parameters, Total anthocyanin and Total phenolics in 2013 season.

Treatments	L	a	b	Chroma	HUE	CIRG Index	Total Anthocyanin (mg/kg)	Total Phenolics (mg/kg)
C	41,780a	−5, 067b	13,913a	15,163a	85,677a	1,663b	9,700b	221,653
G1	29,277b	6,557a	2,257b	6,960b	17,877b	4,477a	20,233a	342,65
G2	31,867b	9,360a	4,957b	10,837ab	26,647b	3,607a	21,110a	372,703
P	**	*	**	**	**	**	**	
LSD	3,831	9,732	3,877	4,380	20,774	0,895	6,641	ns

*G1: Girdling at veraison period, G2: Girdling at pea-sized stage, C: Control, Ns: non-significant, * $p < 0,05$ ** $p < 0,01$.*

Table 4. Effects of girdling on colour parameters, Total anthocyanin and Total phenolics in 2014 season.

Treatments	L	a	b	Chroma	HUE	CIRG Index	Total Anthocyanin (mg/kg)	Total Phenolics (mg/kg)
C	44,123a	−5, 040b	13,943a	15,913a	92,413a	1,467b	10,303b	202,403b
G1	33,310b	8,250a	2,497b	7,217b	12,847b	4,190a	23,387a	356,390a
G2	32,267b	10,493a	5,580b	12,120ab	27,620b	3,453a	26,187a	393,400a
P	*	*	**	**	**	**	**	*
LSD	7,758	11,423	7,032	6,358	24,592	1,419	9,846	152,382

*G1: Girdling at veraison period, G2: Girdling at pea-sized stage, C: Control, Ns: non-significant, * $p < 0,05$ ** $p < 0,01$.*

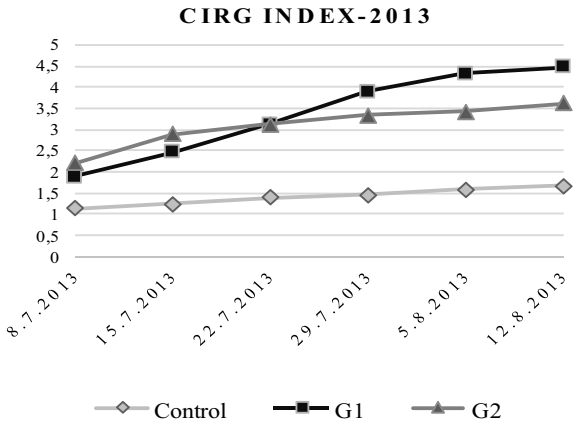

Figure 1. Changing of CIRG Index between veraison and harvest in 2013.

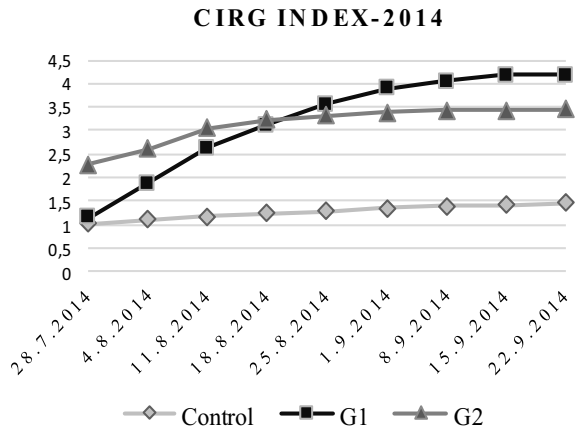

Figure 2. Changing of CIRG Index between veraison and harvest in 2014.

effected statistically by girdling treatments in both years. Especially effects of girdling on CIRG index were found statistically significant ($p < 0,01$). It was observed that higher values were obtained with G1 and G2 treatments compared to the control in both years in terms of CIRG index. This outcome confirms earlier studies. For example, [21,29,31,32] reported that girdling improves coloration and ripening.

In addition the use of colour index for red grapes (CIRG) accepted the definition which categorizes the grape varieties in five groups according to their external colour [33]: green-yellow (CIRG < 2); pink (2 < CIRG < 4); red (4 < CIRG < 5); dark-red (5 < CIRG < 6) and blue-black (CIRG > 6). Also in this study, CIRG Index values were estimated after measurements per each week between veraison and harvesting period in an attempt to observe the colour changes. Figure 1 and Fig. 2 illustrate the changing of CIRG Index values between veraison and harvesting periods in 2013 and 2014 seasons, respectively.

As can be seen in these two figures, it was observed remarkable changes for two growing seasons.

In the first year, G1 and Control treatments had lowest degree of pigmentation and colour of berries was green-yellow at veraison. However it increased to reach the pink with G1 treatments (girdling at veraison) after 1 and 2 weeks of veraison in 2013 and 2014, respectively. Additionally it was observed that colour change was continued for all treatments until harvesting but remarkably G1 treatments had better colour development than the other treatments. At the harvesting period, it was observed Green-Yellow in Control (non-girdling) treatment; Red in G1 (girdling at veraison) and Pink in G2 (girdling at berry size stage) treatment. Similar results were obtained with [34].

It has been reported that grape berry colour can be effected by a number of factors such as cultivar, cultural practices, location and girdling treatments [35]. When the total anthocyanin values have been examined, effect of girdling treatment on total anthocyanin was found statistically significant ($p < 0,01$) in both years. Furthermore total anthocyanin content varied between 9,7–21,11mg/kg and 10,30-26,18mg/kg in 2013 and 2014 seasons, respectively. Also it was observed that G1 and G2 treatments were in the same level group statistically and provided the highest total anthocyanin concentration in both years. As seen in Tables 3 and 4, girdling practices increase berry anthocyanins compared to control vines and similar results were obtained with girdling treatment on red table grape "Aki Queeen" [36]. Also these findings were found similar with earlier researches [19,31,32,37].

In terms of total phenolics, girdling effect was found non-significant in 2013 whereas it was found statistically significant ($p < 0,05$) in 2014 season. Higher values were observed in G2 treatments for both 2013 (372,70 mg/kg) and 2014 (393,40 mg/kg) seasons, in comparison to the other treatments (Tables 3 and 4). Our results are in agreement with [38]. They reported that girdling treatment is leading to more accumulation of phenolics to the remaining upper organs or clusters.

4. Conclusion

Our data provide original (field-based) evidence on mature vines for the finding out of girdling effects at pea-size stage and veraison periods in both two years. Cane girdling treatment at pea-size stage on cv. Flame Seedless increases berry dimensions in two growing seasons. Also berry weight was increased with girdling but it was found out non-significant. On the other hand it can be suggested that girdling at pea-size stage promote total anthocyanin and phenolics accumulation. It was remarkable that colour parameters, especially CIRG index values were increased by girdling at veraison period. Additionally it was found out that girdling accelerates ripenning and provide earliness in both two years.

Over the two years of this study, cane girdling (pea-size stage and veraison period) produced no adverse effects on vine size and therefore, this result may offer a new opportunity for sustainable commercial production of table grapes. However, it needs to be more practice with proper time and achieving better yield with high quality.

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