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The Response of Monoterpene Compounds of cv. Gewürztraminer Grape (*Vitis vinifera* L.) to Various Doses of Prohexadione-Calcium Applied at Different Periods

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Abstract

This study was carried out to determine influences of determine diverse doses of prohexadione-calcium (pro-ca) applied at two different periods such as 1st period (pre-bloom) and 2nd period (post-bloom) on monoterpene compounds and other grape quality attributes of cv. Gewürztraminer during the growing season of the 2010 in Tekirdag, Turkey. Research was arranged according to two factor-factorial randomized parcels with four replicates. Pro-ca has abilities to control vegetative growth and reduce berry sizes in grapevine. In this study, pro-ca applications caused to improvements in grape monoterpene compounds like free volatile monoterpene (FVT) and potentially volatile monoterpene (PVT) and other quality attributes of cv. Gewürztraminer. Among the application doses, the best results about grape quality characteristics of cv. Gewürztraminer were respectively obtained from pro-ca doses of 200 and 300 ppm when they were especially applied to grapevines at 1st period (pre-bloom).

Keywords: *Vitis vinifera* L., aromatic grape varieties, monoterpenes, plant growth retardants, pro-ca

Introduction

Excessive vegetative growth of grapevine is a main factor associated with uncontrolled shade in grapevine canopy and disease problems, leading to low wine grape and wine quality. Pro-ca treatment is one of the most considerable management tools, which viticulturists or orchardists have available to control vegetative growth and to decrease the incidence and severity of some disease in growing of grape and other fruit species (Greene, 2007).

Various chemicals such as chlormequat chloride (Bahar et al., 2009), paclobutrazol (Reynolds et al., 1992) and pro-ca (Giudice et al., 2003; 2004; Kok et al., 2013) have been used in viticulture to decrease excessive growth and restrict growth at a certain time to create a better balance between vegetative growth and cropping level of grapevine.

Among these chemicals, pro-ca is a relatively recent growth retardant and a lot of reports have confirmed that it is influential growth retardants for different plant species (Basak, 2004; Giudice et al., 2003; 2004; Altintas, 2011; Kok et al., 2013).

It is well known that pro-ca applications can lead to reductions in shoot growth of grapevine (Giudice at al., 2003) and grape size (Giudice at al., 2004) depending on application times and doses of pro-ca and also pro-ca applied grape cultivar. A reduce in grape size would lead to an increase in the surface to volume ratio, theoretically increasing the proportion of these flavor and aroma precursors in the must and wine and potentially increasing wine quality.

Monoterpene compounds contribute remarkably to the characteristic flavor of grapes. Linalool, geraniol, nerol, citronellol, and terpeniol from monoterpenes have been identified in *Vitis vinifera* L. grapes (Mateo and Jiménez, 2000) and these are more concentrated in the skin than in the flesh of the berry (Fernandez et al., 1993, Park and Noble, 1993).

Monoterpenes are known as secondary plant metabolites and they consist of two forms, including free volatile monoterpene

(FVT) and potentially volatile monoterpene (PVT). They are largely responsible for aroma and flavor of grape (Mateo and Jiménez, 2000) and the quantity of monoterpenes can rise during the grape maturity (Itu et al., 2011).

The aim of this study is determine effects of pro-ca on monoterpene compounds of cv. Gewürztraminer when applied to different doses and periods.

Materials and Methods

Characteristics of research area, plant material and growing conditions

This research was performed during the vegetation period of 2010 at a commercial vineyard located at Tekirdag province in Turkey (lat. 41º00´40.87´´N; long. 27º39´14.70´´E, 62 m., a.s.l.). In the study, it was utilized from cv. Gewürztraminer's grapevines, 14-year old and grafted on 5BB rootstock (*Vitis* berlandieri x *Vitis* riparia). They were trained to vertical trellis on a bilateral cordon system with 8 spur with 2 buds per grapevine and spaced at 2.5 x 1.25 m. In the course of growing season, standard canopy management practices were applied to grapevines in the vineyard.

The climate is commonly mild in research area and average values of annual temperature, precipitation and wind speed were successively 15.1 ºC, 716.1 mm and 3.10 m/s in 2010 year. Moreover, soil property of study area is generally a silty clay loam texture.

Foliar pro-ca treatments and their application periods

In the study, pro-ca applied as Apogee® (27.5% prohexadione-calcium, BASF Corp., Research Triangle Park, N.C.) was used to inhibit plant growth at a certain time to create a better balance between vegetative growth and cropping level of cv. Gewürztraminer's grapevines. For this purpose, 0, 100, 200 and 300 ppm doses of pro-ca were preferred and applied as three times at 15 day interval for 1st period (pre-bloom period; 1st application: 15 day before blooming; 2nd application: at blooming; 3rd application: 15 day after blooming; respectively) and 2nd period (post-bloom period; 1st application: at blooming; 2nd application: 15 day after blooming; 3rd application: 30 day after blooming; respectively) in cv. Gewürztraminer's grapevines (Table 1). In 2010, beginning date of blooming period in cv. Gewürztraminer's grapevines was about June 3.

Table 1. Application periods of pro-ca according to dates in cv. Gewürztraminer

1st period			2nd period		
1.Application	2.Application	3.Application	1.Application	2.Application	3.Application
May 19	June 3	June 18	June 3	June 18	July 3

Quality and yield parameters

In present study, various quality (i.e., total soluble solids (TSS, %), titratable acidity (TA, g l^{-1}), pH, free volatile terpene (FVT, mg l^{-1}), potentially volatile terpene (PVT, mg l^{-1})) and yield (i.e., berry length (BL, mm), berry width (BWi, mm), berry weight (BWe, g), cluster length (CL, cm), cluster width (CWi, cm), cluster weight (CWe, g)) parameters were assessed.

Berry sampling and preparation

Four 100- and four 250- berry samples were collected from each treatment replicate at harvest time, which occurred on 31 August 2010 for laboratory analyses. The 100-berry samples were used to find out BL, BWi, BWe, CL, CWi, CWe, TSS, TA and pH. It was also made use of the 250-berry samples to determine monoterpene analyses such as FVT and PVT and berry samples were stored at -25ºC until analysis time for this goal. Before the analyses, frozen berry samples were removed from -25ºC and allowed to thaw overnight at 4ºC and homogenized in a commercial laboratory blender for 20 s.

Monoterpene analyses

Monoterpene analyses such as contents of FVT and PVT were conducted on the berry samples from harvest date, using a previous method of Dimitriadis and Williams (1984) as modified by Reynolds and Wardle (1989 a).

Statistical analyses

Research design was based on two factor-factorial randomized parcels with four replicates. Analysis of variance (ANOVA) was performed to determine the effects of variable factors on monoterpene compounds and other

quality parameters by using TARIST statistical software programme. In order to determine the significance of differences among means, L.S.D. multiple range test method was used at significance level of 5 % (Table 2).

Results

In present study, it was paid attention to interactions among the application doses and application periods of pro-ca and differences among them were not statistically found to be significant at 5 % level for all quality and yield parameters (Table 2).

Quality parameters

Based on pro-ca application periods (1st and 2nd period, $P \geq 0.05$), TSS content means of cv. Gewürztraminer ranged from 20.88-19.83 % for 0 ppm to 24.03-23.33 % for 200 ppm (Table 2).

On the other hand, TA means of cv. Gewürztraminer in both 1st and 2nd periods showed a significant decrease in grapes of 200 ppm pro-ca applied grapevines (6.19-6.78 g l^{-1}) and an increase in grapes of 0 ppm pro-ca applied grapevines (7.69-7.72 g l^{-1}) (Table 2, $P \geq 0.05$).

Regarding pH of grape must displayed in Table 2, no differences were statistically found in both periods at significance level of 5%, but 200 ppm pro-ca applied grapes generally exhibited higher pH values like 3.49 and 3.47 than 0 ppm applications (3.38-3.36).

As displayed in Table 2 ($P \geq 0.05$), the contents of FVT in pro-ca applied grapes increased with the rising doses from 0 ppm (0.580-0.565 mg l^{-1}) to 200 ppm (0.970-0.853 mg l^{-1}) in both periods.

In terms of the PVT content in both periods, the trend of PVT content in grapes was similar to that FVT content and PVT contents in both periods were affected by doses from 0 ppm (1.510-1.475 mg l^{-1}) to 200 ppm (2.130-1.898 mg l^{-1}) with increasing doses resulting in enhancement of PVT content (Table 2, $P \geq 0.05$).

Yield parameters

In terms of BL and CL means, the differences among the dose levels of pro-ca in both periods were not statistically ascertained to be significant at 5% level as shown in Table 2.

Concerning BL characteristics of cv. Gewürztraminer ($P \geq 0.05$), 200 ppm pro-ca applications gave the lowest means (12.47-12.98 mm) and the highest means were obtained from 0 ppm (14.01-14.07 mm) in both periods (Table 2).

Similarly, increasing pro-ca doses from 0 ppm (14.89-14.94 mm) to 200 ppm (12.63-13.35 mm) in both periods adversely affected BWi characteristics of cv. Gewürztraminer (Table 2, $P \geq 0.05$).

As presented in Table 2, the BWe means of 0 ppm was higher (1.77-1.86 g) than of from 100 ppm (1.66-1.78 g) to 200 ppm (1.45-1.59 g) in both periods ($P \geq 0.05$).

Higher means of CL in both periods were obtained from grapes applied at doses of pro-ca from 0 ppm (11.35-11.27 g) to 200 ppm (8.97-9.61 g) indicated in Table 2 ($P \geq 0.05$).

Table 2. Effects of various doses of pro-ca applied at different periods on quality and yield characteristics of cv. Gewürztraminer

	0 ppm		**100 ppm**		**200 ppm**		**300 ppm**		**Level of significance**
Quality parameters	1st period	2nd period	1st period	2nd period	1st period	2nd period	1st period	2nd period	
TSS (%)	20.88	19.83	21.93	20.81	24.03	23.33	23.24	22.97	N.S.
TA (g l^{-1})	7.69	7.72	7.03	7.44	6.19	6.78	6.84	7.28	N.S.
pH	3.38	3.36	3.46	3.41	3.49	3.47	3.47	3.45	N.S.
FVT (mg l^{-1})	0.580	0.565	0.795	0.673	0.970	0.853	0.850	0.748	N.S.
PVT (mg l^{-1})	1.510	1.475	1.855	1.790	2.130	1.898	1.895	1.845	N.S.
	0 ppm		**100 ppm**		**200 ppm**		**300 ppm**		**Level of significance**
Yield parameters	1st period	2nd period	1st period	2nd period	1st period	2nd period	1st period	2nd period	
BL (mm)	14.01	14.07	13.38	13.55	12.47	12.98	12.88	13.21	N.S.
BWi (mm)	14.89	14.94	13.94	14.00	12.63	13.35	13.05	13.47	N.S.
BWe (g)	1.77	1.86	1.66	1.78	1.45	1.59	1.58	1.76	N.S.
CL (cm)	11.35	11.27	10.38	10.76	8.97	9.61	9.81	10.02	N.S.
CWi (cm)	10.46	10.12	9.64	9.97	8.21	8.84	8.52	9.67	N.S.
CWe (g)	170.17	173.31	143.43	163.44	113.70	149.04	133.64	158.72	N.S.

Means with the same letter in a column are not statistically significant different from each other according to the L.S.D. test at P≤0.05

Although pro-ca doses were not differing statistically ($P \geq 0.05$) in CWi characteristics of cv. Gewürztraminer, 0 ppm led to the highest means of CWi (10.46-10.12 cm) and 200 ppm caused the lowest means (8.21-8.84 cm) in both periods demonstrated in Table 2.

With rising doses of pro-ca applications brought about decrease in CWe of cv. Gewürztraminer ranged from 0 ppm (170.17-173.31 g) to 200 ppm (113.70-149.04 g) at significance level of 5% (Table 2).

Discussion

Pro-ca applications can lead to reductions in grape sizes depending on doses and application times of pro-ca in wine grape growing (Giudice at al., 2004). It is also well known fact that a decrease in grape size would lead to an increase in the surface to volume ratio, theoretically increasing the proportion of these flavor and aroma precursors in the must and wine and potentially increasing wine quality.

As seen in Table 2, 1st period (pre-bloom) was more effective than 2nd period (post-bloom) for pro-ca applications in cv. Gewürztraminer and berry and cluster sizes were conversely affected by elevating pro-ca doses, leading to enhancements in quality characteristics of cv. Gewürztraminer.

Conclusion

Monoterpene compounds are important for grape aromas and flavors and are responsive to seasonal differences, winemaking practices and viticultural practices. Among these viticultural practices, chemical applications, inhibiting gibberellin biosynthesis are important for reducing excessive growth and restrict growth at a certain time to create a better balance between vegetative growth and cropping level of grapevine.

As a result, pro-ca doses of 200 and 300 ppm respectively applied to grapevines of cv. Gewürztraminer at 1st period (pre-bloom) particularly caused improvements in monoterpene compounds and also other quality attributes in grapes.

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