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INFLUENCES OF VARIOUS CANOPY MANAGEMENT TECHNIQUES ON WINE GRAPE QUALITY OF *V. VINIFERA* L. CV. KALECIK KARASI

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Abstract

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This experiment was carried out to improve wine grape quality of cv. Kalecik Karasi by means of different canopy management techniques such as control (C), cluster thinning (CT), hedging (H), pro-calcium (ProCa), hedging plus pro-calcium (H+ProCa) during the 2010 vegetation period. In current study, the findings indicated that all canopy management treatments increased wine grape quality characteristics. While the effects of different canopy management techniques on quality and yield were varying, the best results concerning total soluble solids, total phenolic compound content and anthocyanin content, which are important for wine grape quality were respectively obtained from CT, ProCa, H, H+ProCa and C treatments.

Key words: Vitis vinifera L., grapevine, canopy, canopy management, wine grape, wine grape quality

Introduction

Grape quality is a complex concept that mainly refers to grape chemical composition, including sugars, acids, phenolic and other aroma compounds (Lund and Bohlmann, 2006; Conde et al., 2007) and is affected by various conditions such as genotype, environment, viticultural management (Jackson and Lombard, 1993; Dai et al., 2010; Kok, 2011; Korkutal, 2011).

Growing of well-qualified grapes has become increasingly important for wine industries of world countries. Recently, there has been an emphasis by the industry to improve quality through decreasing yield. Regardless of genotype and environment, various viticulture practices such as precise canopy management, irrigation, choice of suitable training systems and rootstocks can be used to enhance grape quality and buffer unfavorable natural conditions (Zsofi et al., 2009).

Among these viticulture practices, canopy management has crucial role on grape quality and there has been much recent interest in the effects of canopy management on grape composition and wine quality. Canopy management is described as range of techniques imposed by a grape grower on a vineyard resulting in altered position or amount of leaves, shoots and fruit in space to achieve some desired arrangement (Smart, 1992). The main emphasis of canopy management is usually to decrease excessive canopy shading and is designed to control grapevine vigor and yield; enhance grape ripening and decrease susceptibility to fungal diseases. These techniques include trellis-training systems, control of shoot number, their spacing and positioning, leaf removal in fruiting zone, hedging, cluster thinning, their combinations. These practices have been established with the goal of optimizing sunlight interception, photosynthetic capacity and cluster microclimate to improve yield and wine quality, especially in vigorous and shaded vineyards (Smart et al., 1990). In grape growing, excessive canopy shade can decrease grape and wine quality owing to reductions in some of the light-dependent constituents of berry (Dokoozlian and Kliewer, 1995, 1996). Besides, dense canopy of grapevine may increase the incidence of fruit rots favored by increased humidity, leaf wetness and reduced wind speeds measured within canopies (English et al., 1989).

Apart from classic canopy management techniques, inhibitors of gibberellin biosynthesis are also used to restrict vegetative growth and prevent dense canopy of grapevine (Reynolds et al., 1992). For this purpose, it can be extensively utilized from different chemical compounds in plant species like chlormequat chloride (Bahar et al., 2009), paclobutrazol (Reynolds et al., 1992; Wolf et al., 1991), prohexadione-calcium (Altintas, 2011; Giudice et al., 2003; Giudice et al., 2004).

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The purpose of present study was to ascertain whether canopy manipulations, alone or in combinations, might have an impact on wine grape composition of cv. Kalecik Karasi.

Material and Methods

Vineyard site, experimental design and growing conditions. The field trial was carried out in vegetation period of 2010 at a commercial vineyard located at Tekirdag in Turkey (long. 41° 00' N; lat. 27° 39' E; 62 m. a.s.l.). In the research, cv. Kalecik Karasi, whose grapevines are the 14-year-old and grafted on 5BB (*Vitisberlandieri* x *Vitisriparia*) at a spacing of 2.5 m. by 1.25 m was used for planting material. Grapevines were trained to a vertical trellis on a bilateral cordon system oriented in North-South direction. Trunk heights of grapevines were 0.5 m and were spur-pruned (8 spur with 2 buds per grapevine).

The climate of experiment area is of the Mediterranean type; with hot and dry summers and mild rainy winters. Some important climate characteristics of 2010 were 716.1 mm, 15.1°C and of 1776-degree days for total annual precipitation, annual mean temperature, heat summation, respectively.

Experiment soil presents a silty clay loam texture with the following mean characteristics; clay 35.78 %; silty 32.46 %, sand 31.76 %; organic matter 1.16 %; pH 7.74.

Canopy management techniques used in research. In present research, it was utilized from five different canopy management techniques; including control, cluster thinning, hedging, pro-calcium and hedging plus pro-calcium.

1- Control (C); consisted of dormant hand pruning to 16 buds; two-node spurs with no further manipulation for each grapevine.

2-Cluster thinning (CT); clusters of shoots on the grapevine were thinned to one cluster per shoot at growth stage of 35 (vérasion) defined according to the scheme of Eichhorn and Lorenz (1977) on 31 July 2010.

3- Hedging (H); grapevines were hedged to 15 leaves per shoot at growth stage of 31 (berries pea-size; 7 mm diameter) defined according to the scheme of Eichhorn and Lorenz (1977) on 30 June 2010.

4- Pro-calcium (ProCa); pro-calcium treatments were respectively performed three times which included those two pre-bloom applications on May 14 at growth stage of 15 (8 leaves separated; single flowers in compact groups), June 4 at growth stage of 19 (about 16 leaves separated, beginning of flowering; first flower caps loosing) plus a post-bloom on July 2 at growth stage of 31 (berries pea-size -7 mm diameter) (Eichhorn and Lorenz, 1977).

5- Hedging plus pro-calcium (H+ProCa); a pro-calcium was applied to grapevine canopy one week after shoot hedging on 7 July 2010. For this aim, dose of 250 mg L^{-1} was used to inhibit of gibberellin biosynthesis and reduce shoot elongation (Giudice et al., 2003).

Examined parameters in the research. Grape quality characteristics and yield components such as total soluble solids (%), titratable acidity (g/L), must pH, total phenolic compound content (mg/kg) and anthocyanin content (mg/100g), berry length (mm), berry width (mm), berry weight (g), cluster length (cm), cluster width (cm), cluster weight (g) were assessed in the study.

Grape sampling and harvest. Four 100- and four 250-berry samples were collected from each treatment replicate at harvest, which occurred on 16 September 2010 for laboratory analyses. The 100-berry samples were used to find out berry length, berry width, berry weight, cluster length, cluster width, cluster weight, total soluble solids, titratable acidity and pH. It was also utilized from the 250-berry samples to determine total phenolic compound content and anthocyanin content and samples were stored at -25°C until analysis time for this aim. Before the analyses, frozen grape samples were removed from -25°C and allowed to thaw overnight at 4°C and homogenized in a commercial laboratory blender for 20s.

Laboratory analysis: In order to determine total phenolic compounds content and anthocyanin contentin cv. Kalecik Karasi, it was respectively utilized from spectrophotometricmethods informed by Singleton et al. (1978) and Di Stefano and Cravero (1991).

Statistical analysis. In present study, the experimental design was completely randomized blocks with five different canopy management techniques and four replicates consisting of two grapevines for each. All analyses of variance were performed using SPSS statistical package (18.0 for Windows). Differences due to various canopy treatments were tested for statistical significance at p=0.05 level and Tukey's t-test was used to differentiate between the mean values.Data were presented as mean ± standard error (SE).

Results and Discussion

Wine grape quality may be associated with sugar accumulation, total acidity, tannin content and anthocyanin content (Freeman and Kliewer, 1983). Grapes are harvested when they reach a stage for sale or processing. Percentage soluble solids is used as a chief measure of the suitability for harvest and wine grapes are harvested at range of soluble solids, from 17-30 % (Janick and Robert, 2007). As represented in Figure 1, it could be observed that percentages of total soluble solids were affected by canopy management techniques, while control was the lowest and the order being CT (23.58%) > H (22.14%) >ProCa (21.98%) >H+ProCa (21.15%) > C (20.08%).

The acidity of grape juice has a direct impact on its sensory quality and physical, biochemical and microbial stability (Boulton et al., 1998). The acidity and especially pH affect many wine parameters such as survival and growth of all microorganisms and freshness of some wine styles. In this study, no statistically differences were found in terms of titratable acidity, however, means reached were within the optimal range at harvest for C (10.62 g/L), CT (9.81 g/L), H (9.91 g/L), ProCa (9.84 g/L) and H+ProCa (9.97 g/L) (Figure 2).

It is important to harvest at low pH like 3.3-3.4 to maintain stable color in processed juice (Bates et al., 2001). In terms of must pH, significant differences among canopy management techniques can be seen in Figure 3. The highest must pH values were respectively achieved in CT (3.40), H+ProCa (3.36), H (3.31), ProCa (3.30) and C (3.27).

The maturity of grape at harvest time will find composition and as a result the potential aroma and quality of the wine. Chemical compounds in wine grapes play vital roles on vinification. Wine contains a plenty of phenolic compounds, which derive from the grapes (Adams, 2006; Eder and Wendelin, 2002). Phenols contribute to red pigmentation, the brown-forming substrates and the bitter and astringent components and to a small extent, the taste in grapes and wine. Figure 4 shows total phenolic compound contents in grapes of cv. Kalecik Karasi according to canopy management techniques. Results from present study shown that mean values of total phenolic compound content from high to low were respectively 3028.26 mg/kg (for CT), 2443.51 mg/kg (for ProCa), 2234.37 mg/kg (for H), 2123.57 mg/kg (for H+ProCa) and 1675.67 mg/kg (for C).

Grape skin color is another important factor affecting wine quality. Anthocyanins are water soluble, vacuolar pigments, responsible for coloration of fruits, flowers, stems and leaves in most of the higher order plants (Van Buren, 1970; Ribéreau-Gayon et al., 2000). It has been shown that quantity and composition of these anthocyanins affect skin color of grapes (Shiraishi and Watanabe, 1994; Ribéreau-Gayon et al., 2000). Anthocyanin contents in grape skins of various canopy management techniques applied grapevines are presented in Figure 5. Analysis results represented that means of

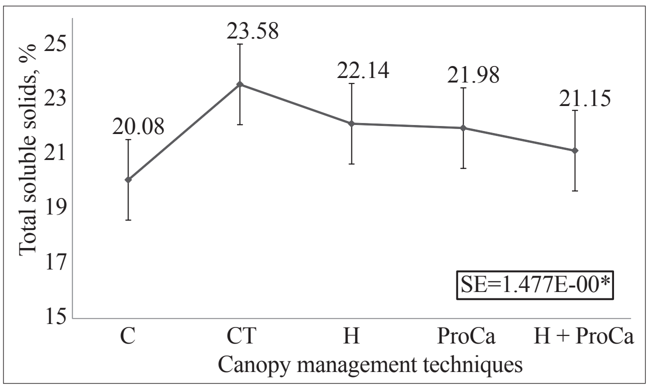

Fig. 1. Influences of different canopy management techniques on total soluble solids

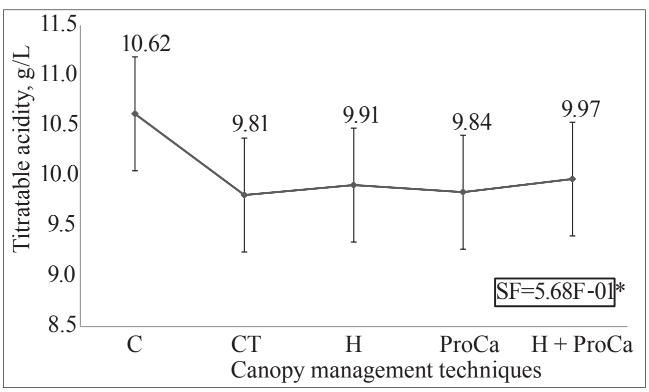

Fig. 2. Influences of different canopy management techniques on titratable acidity

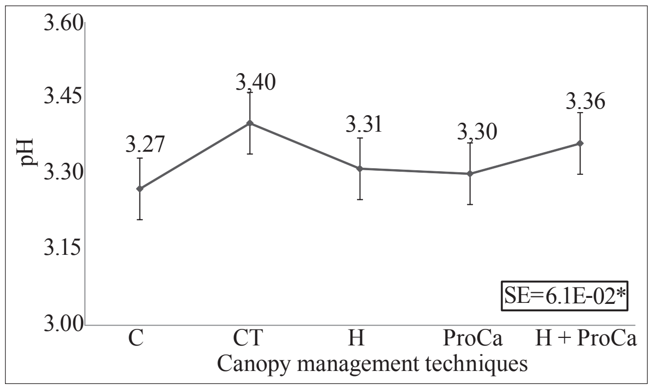

Fig. 3. Influences of different canopy management techniques on must pH

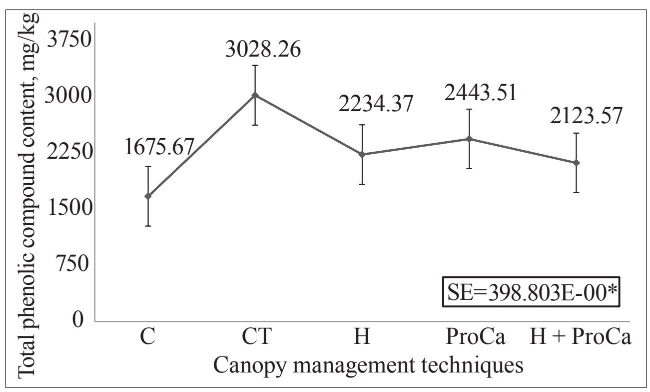

Fig. 4. Influences of different canopy management techniques on total phenolic compound content

anthocyanin content in berries of canopy management techniques applied grapevine were higher compared with control and values were 67.06 mg/100 g (for CT), 64.45 mg/100 g (for ProCa), 62.38 mg/100 g (for H), 61.94 mg/100 g (for H+ProCa) and 23.22 mg/100 g (for C).

Grape development begins with flowering and flower starts to grow and develop into a berry after fertilization (Jackson, 2000). Berry size is broadly accepted as a factor determining wine grape quality. In wine grape growing, there is demand in not only small berry and cluster but also abundant grape must. Effects of various canopy management techniques on berry characteristics are represented in Figures 6, 7, 8 and all of them were statistically found to be significant. In present study, means of berry length were significantly affected by canopy management practices and mean values were16.09 mm (for C),16.49 mm (for CT), 16.23 mm (for H), 14.19 mm (for ProCa) and16.18 mm (H+ProCa) (Figure 6).

Several studies demonstrate the importance of the berry size as a growing and quality indicator (Roby et al., 2004). As presented in Figure 7, canopy management techniques had significant effects on berry width and means of berry width were 14.76 mm for C,15.46 mm for CT, 15.23 mm for H, 13.27 mm for ProCa and15.31 mm for H+ProCa,

Based on berry weight, canopy management techniques appeared to affect the berry weight and means from high to low were 2.95 g (for CT), 2.94 g (for H), 2.86 g (for H+ProCa), 2.85 g (for C) and 1.81 g (for ProCa) (Figure 8).

Means of cluster characteristics of cv. KalecikKarasi are shown in Figure 9, 10, 11. Non statistically differences were observed between control and other canopy management techniques. Means of cluster length were successively 15.04 cm (for C), 15.44 cm (for CT), 15.97 cm (for H), 14.60 cm (for ProCa) and 14.77 cm (for H+ProCa) (Figure 9).

As seen in Figure 10, there were no significant relationships among the canopy management techniques in terms of cluster width. Among these, higher mean values were obtained from H (11.07 cm), CT (10.56 cm), C (9.36 cm), ProCa (8.98 cm) and H+ProCa (8.90 cm).

Different treatments of canopy management had statistically significant impacts on cluster weight of cv. Kalecik

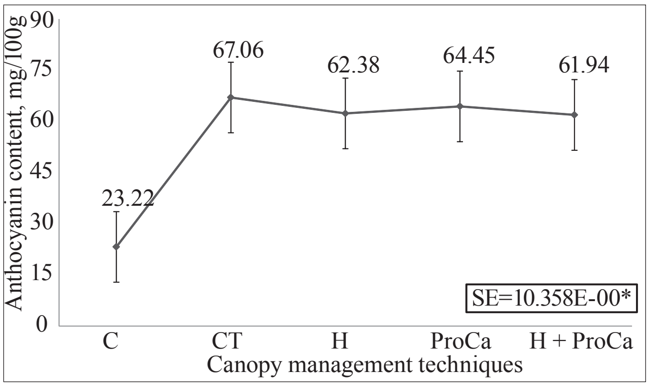

Fig. 5. Influences of different canopy management techniques on anthocyanin content

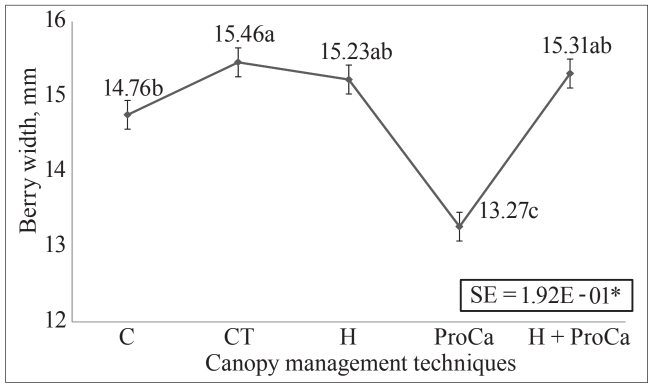

Fig. 7. Influences of different canopy management techniques on berry width

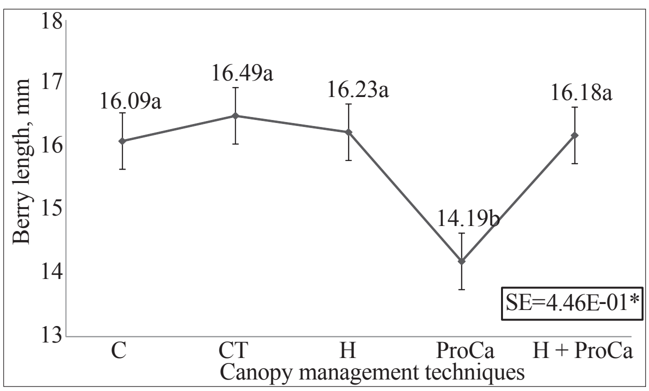

Fig. 6. Influences of different canopy management techniques on berry lenght

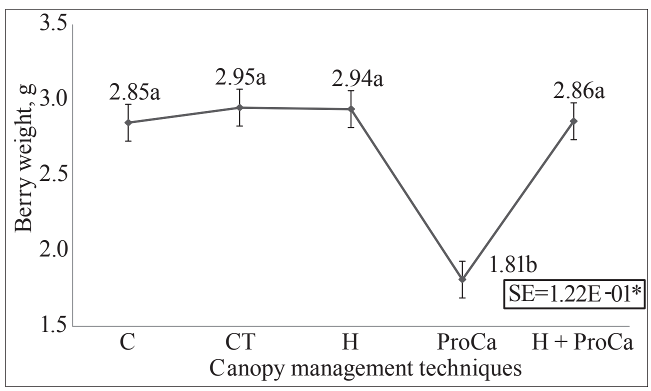

Fig. 8. Influences of different canopy management techniques on berry weight

Karası and these canopy management techniques from CT, H, H+ProCa, C to ProCa led to increases in cluster weight for CT (282.41 g), H (266.63 g), H+ProCa (217.75 g), C (188.59 g) and ProCa (175.94 g) (Figure 11).

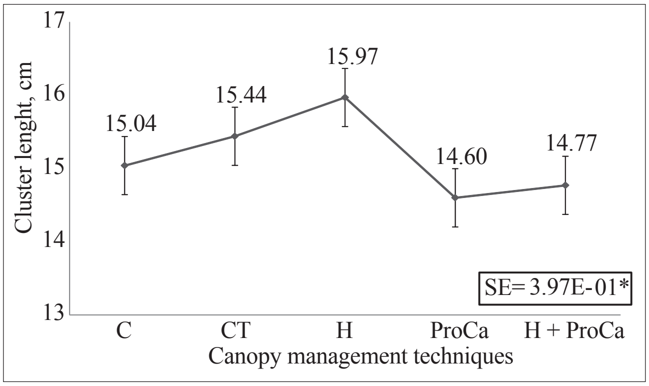

Fig. 9. Influences of different canopy management techniques on cluster lenght

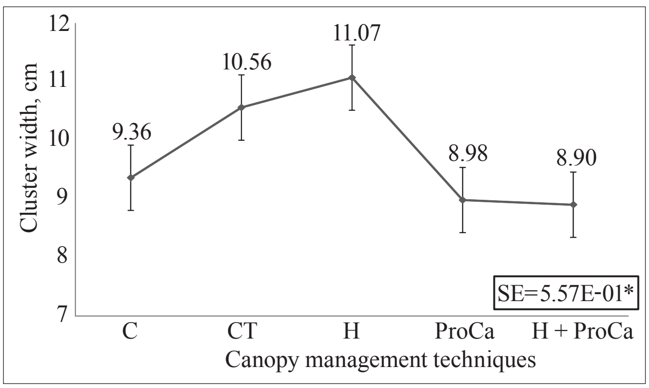

Fig. 10. Influences of different canopy management techniques on cluster width

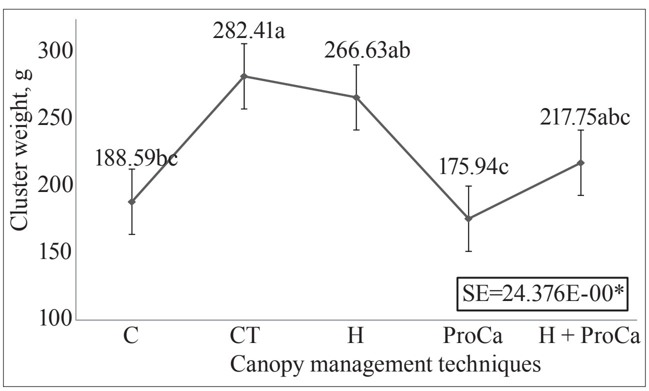

Fig. 11. Influences of different canopy management techniques on cluster weight

Conclusions

In wine grape growing, an excess of vigor and shading lead to low grape quality and shading in grapevine canopy. Grapes developing in open conditions have generally higher total soluble solids, improved acid balance as lower juice pH and higher titratable acidity, less incidence of unripe herbaceous grape attributes and often raised concentration of berry phenolics than in shaded canopy conditions. The impact of canopy management practices such as cluster thinning, basal leaf removal, hedging, applications of GA_3 inhibitors such as ProCa, CCC, paclobutrazol can be a function of minimizing intra-grapevine competition for carbohydrates in addition to their obvious role in the enhancement of cluster microclimate. It is well known in wine grape growing that alterations in canopy management may result in considerable improvements in yield and grape composition and provides a set of tools allowing viticulturists to improve the canopy structure and microclimate of grapevine that affect wine grape quality. In present study, some of these canopy management techniques were compared with each other. The results of study indicated that each of various canopy management techniques, alone or in combination, had crucial impacts on characteristics of cluster, berry and berry quality and findings also confirmed that CT, ProCa, H, H+ProCa, C treatments successively resulted in improvements in wine grape quality of cv. Kalecik Karasi.

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