The Effect of Training System and Yield on Fruit Quality of 'Marquette' and 'La Crescent' Wine Grapes (*Vitis* spp.) in a Vermont Vineyard

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Abstract

The objective of this study was to determine the effect of training system and yield on fruit quality parameters of 'Marquette' and 'La Crescent' (*Vitis* spp.) wine grape cultivars in a Vermont vineyard. The grapevines studied were grown at Lincoln Peak Vineyard in New Haven, VT. Three training systems were sampled with 'Marquette': Geneva Double Curtain (GDC), Single Wire (SW) and Vertical Shoot Position (VSP). Fruit of 'La Crescent' was sampled from only the GDC and SW training systems. Fruit quality parameters measured included soluble solids concentration, pH, and titratable acidity of the juice. The balance of these parameters may be indicative of final wine quality and may enable growers to optimize vineyard management in cold climates. Significant differences in yield and quality measures were found among training systems. While many quality parameters were impacted by the training system, variation in yield among vines accounted for little of the variation. For both cultivars, GDC trained vines produced the highest yields without compromising fruit quality.

Introduction

Reduced fruit quality in wine grape is commonly perceived to go hand in hand with high yields. Increasing yields without good vineyard management practices can lead to reduction in sugar concentration, lower pH and higher titratable acidity as the plant partitions finite resources into a larger number of berries (3). Fruit quality and other characteristics can be influenced by various technical and environmental factors such as climate, cultivar, training system, vine microclimate management, and soil. Hence it is important to find a balance between these parameters in order to optimize yield without compromising quality (4).

The extent to which fruit quality depends on yield and training system may also depend on the grape cultivar, vineyard management, and whether a cultivar is adapted to the climate where it is grown (4, 6). In locations such as Vermont, climate is a significant limiting factor for winemakers as few cultivars of grapes are able to survive the harsh winters and produce

high quality fruit in the short summers of the North Eastern United States (1, 13). Vines can experience temperatures as low as -30°C in winter and killing frosts in the spring and fall that can significantly influence yield and fruit quality (5). While several studies have looked at the relationships between training system, yield and fruit quality (3, 7, 8, 9, 10, 11), no study has yet examined the effects of training system and yield on the neo-American grape cultivars, 'Marquette' and 'La Crescent', able to survive the cold winters of places such as Vermont.

This study evaluated the effect of training system on yield and fruit quality factors of 'Marquette' and 'La Crescent' cultivars grown in a Vermont vineyard.

Materials and Methods

This study was conducted at Lincoln Peak Vineyard in New Haven, Vermont during the 2009 growing season. 'Marquette' and 'La Crescent' vines were sampled from different training systems distributed throughout the

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12-acre vineyard in order to test whether there was a relationship between yield and differences in soluble solids concentration, pH, and titratable acidity amongst different training systems. The soil type in the vineyard is an Amenia stony silt loam with a subtending clay subsoil layer at 46 cm depth. Tile drains were installed to mitigate drainage issues from the clay subsoil. Soil samples were taken from different sections of the vineyard to ensure that there was no significant variation in nutrient levels across the vineyard.

The vineyard was established in 2001 with some replanting in 2002 and 2003. The vines in this study were either 6 or 7 years old although exact age of each vine was not known. Vine growth was not specifically measured. Vines were selected by randomly choosing a vine within the first ten vines in the Northwest corner of the vineyard. Using this vine as a starting point, every tenth vine was sampled. In some instances, a training system was located in more than one area of the vineyard and separate locations were regarded as sections. For 'Marquette', 25 vines were randomly selected on the vertical shoot position (VSP) training system, 25 vines on the single wire high cordon (SW) training system, and 50 vines (two sections of 25 each) on the Geneva double curtain (GDC)

training system. For 'La Crescent', 50 vines were sampled (two sections of 25 each) on the GDC training system and 50 vines (one section of 15 and one section of 35) on the SW training system (training system section selections were determined by the layout of the vineyard). 'La Crescent' was not trained on the VSP training system.

'Marquette' grapes were harvested between 30 September and 6 October, 2009 and 'La Crescent' grapes were harvested between 10 October and 15 October, 2009. Vines within the experiment were harvested within a day of when other vines in the same section of the vineyard were harvested for commercial winemaking. All of the grapes from each vine were harvested and total yield, average cluster weight, and average berry weight were measured (Tables 1 and 2). A sample of 100 berries from each vine was juiced and frozen at -35 °C for further analysis.

For every vine sampled, soluble solids concentration (°Brix) (using a hand refractometer), pH, and titratable acidity (Zoecklein *et al.* 1996) were measured.

'Marquette' and 'La Crescent' cultivars were analyzed separately for all analyses. A one-way ANOVA was conducted in order to determine whether means for yield and fruit quality variables were significantly different

Table 1: Means (+/- standard error) for yield and fruit quality parameters among training systems for Marquette grapevines. GDC is the Geneva Double Curtain training system, SW is the single wire system, and VSP is the Vertical Shoot Position system. Means with different superscript letters differ significantly ($P<0.05$).

	Training system			
	GDC	SW	VSP	Significance
Total yield per vine (kg)	10.0 ± 0.6[a]	6.1 ± 0.5[b]	2.1 ± 0.2[c]	<0.001
Yield (kg)per meter row	4.1 ± 0.3[a]	2.5 ± 0.2[b]	0.9 ± 0.1[c]	<0.001
Yield (kg) per hectare	11200 ± 700[a]	9040 ± 810[a]	3100 ± 300[b]	<0.001
Average cluster weight (g)	86.0 ± 3.4[a]	72.3 ± 3.7[b]	43.3 ± 2.2[c]	<0.001
Average berry weight (g)	1.4 ± 0.0[b]	1.5 ± 0.02[a]	1.2 ± 0.0[c]	<0.001
Soluble Solids (°Brix)	27.1 ± 0.2[b]	26.6 ± 0.2[b]	28.0 ± 0.2[a]	<0.001
pH	3.1 ± 0.0[b]	3.2 ± 0.0[a]	3.1 ± 0.0[b]	<0.001
Titratable acidity (g·L^{-1})	8.3 ± 0.1[a]	8.0 ± 0.1[ab]	7.6 ± 0.2[b]	<0.001

Table 2: A one-way ANOVA was performed on the means of various wine quality measures and compared across training systems for La Crescent vines. After correcting for error using Bonferroni's correction, a significance value of <0.004 is considered statistically significant. Bolded rows are statistically significant, shaded rows are not. Means and standard errors from each training system are reported in the columns on the right.

	Training system		
Wine quality parameter	GDC	SW	Significance
Total yield per Vine (kg)	**10.9 ± 0.7**	**6.5 ± 0.4**	**<0.001**
Yield (kg) per meter row	**4.5 ± 0.3**	**2.3 ± 0.17**	**<0.001**
Yield (kg) per hectare	**11700 ± 710**	**7910 ± 640**	**<0.001**
Average cluster weight (g)	87.8 ± 2.1	83.3 ± 2.6	0.396
Average berry weight (g)	**1.3 ± 0.0**	**1.4 ± 0.0**	**<0.001**
Soluble solids (°Brix)	27.2 ± 0.2	26.5 ± 0.2	0.008
pH	**3.0 ± 0.02**	**3.2 ± 0.0**	**<0.001**
Titratable acidity (g/L)	9.4 ± 0.2	10.1 ± 0.2	0.015

among training systems. F-tests were considered significant if P<0.05. Pearson's correlation coefficients were calculated between yield per vine and the various fruit quality parameters for all vines in order to determine if there was a significant relationship between yield and fruit quality. In order to determine how much of the variation in fruit quality was explained by yield, yield per vine and fruit quality parameters across all training systems as well as within each training system were correlated. Relationships were considered significant if P<0.05.

Results

For 'Marquette', yield (yield per vine, yield per meter row, and yield per hectare) was significantly higher in GDC vines than in either VSP or SW vines (Table 1). Soluble solids concentration was significantly lower in GDC and SW vines than in VSP vines but differences between GDC and SW vines were not significant (Table 1). The pH was significantly higher in SW vines than in either VSP or GDC trained vines (Table 1). Titratable acidity was highest in GDC vines and lowest in VSP vines. Titratable acidity in the GDC system was significantly higher than in the VSP system with vines on the SW

system being intermediate (Table 1). While yield varied significantly amongst training systems, it did not account for differences seen in quality parameters (Figure 1). Titratable acidity and soluble solids concentration exhibited no correlation with yield (p>0.05 for Pearson's correlation coefficients). Even though some quality measures were not as high for the GDC training system where yields were highest, all values for these quality measures were acceptable. Thus, with well-maintained GDC vines, the vineyard was able to produce significantly more fruit of a comparably high quality.

A similar trend was observed for 'La Crescent'. Yield (yield per vine, yield per meter row, yield per hectare) was significantly higher in GDC vines than with SW vines (Table 2). However, the only wine quality measure that was significantly different between training systems was pH where the pH in SW vines was significantly higher than the pH of GDC vines (Table 2). Yield per vine was also significantly negatively correlated with pH across training systems: pH decreased as yield increased (Pearson's correlation coefficient N=81, r=-0.524, r²= 0.275, P<0.001). Soluble solids concentration and titratable acidity were not significantly
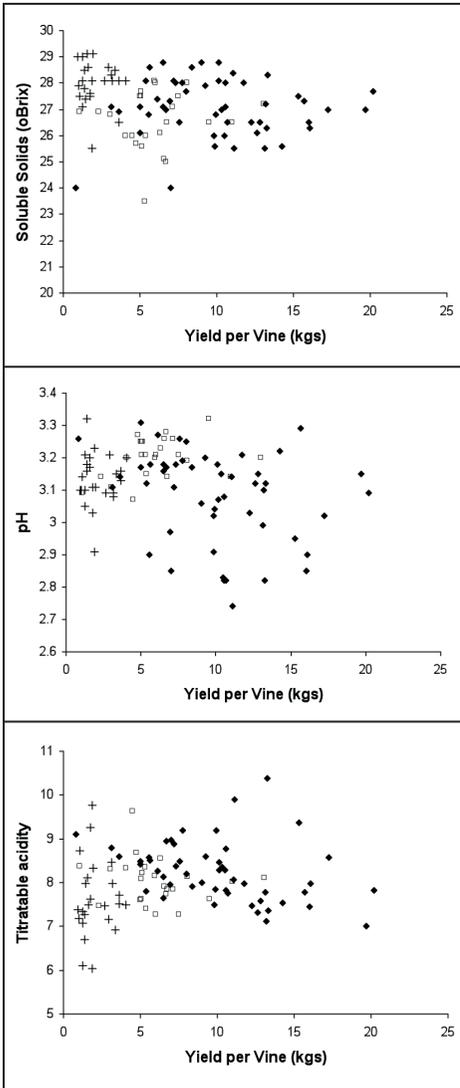
Figure 1. Relationship between yield and various juice characteristics for 'Marquette' vines. Solid diamonds are GCD vines, outlined squares are SW vines and plus signs are VSP vines.
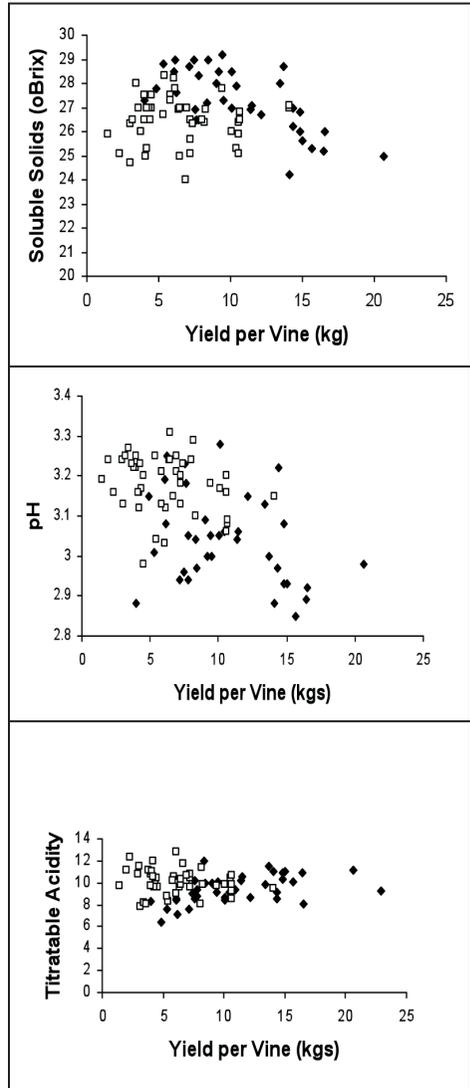

Figure 2. Relationship between yield and various juice characteristics for 'La Crescent' vines. Solid diamonds are GCD vines and outlined squares are SW vines.

different between training systems and neither was significantly correlated with yield across training systems (Figure 2). Thus, even though yield was significantly higher on the GDC training system, quality was not impacted.

Discussion

This study examined the influence of training system and yield on wine quality measures in 'Marquette' and 'La Crescent' grape cultivars in a Vermont vineyard. The

GDC training system appeared to maximize yields for both cultivars while maintaining an acceptably high quality of fruit. While this study only includes data from 2009, past experience within this vineyard corroborates these data. GDC vines have tended to be the highest yielding training system without compromising fruit quality. VSP vines often had higher soluble solids concentration than other training systems but yields were significantly lower. GDC was, therefore, the preferred training system at this vineyard. This suggests that by maximizing photosynthetic efficiency and light availability to clusters, vines are able to ripen large crops with high quality fruit on the GDC system. Significant differences among training systems were observed in both cultivars for many of the wine quality parameters measured and most notably for yield. However, few of the wine quality parameters measured had strong relationships with yield suggesting that with appropriate vineyard management, high yields can be achieved without sacrificing quality within the yield ranges achieved in this study (4, 12).

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