Grapevine nutrition and juice quality

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Background and Rationale: Cold-hardy hybrid wine grape cultivars released by the University of Minnesota have become very important to the wine industry in cold-climate regions of North America. Soil and nutrient management practices to maximize yield and wine quality have not yet been determined for these new cultivars. Our objective is to establish nutrient management guidelines for cold-hardy hybrid wine grapes and to determine the relationships between soil and tissue nutrients on one hand, and juice quality on the other.

Treatments: We selected three cultivars for study:

- Frontenac
- La Crescent
- Marquette

We sampled soil at two depths to determine nutrient concentrations and other characteristics:

- 0 to 8 inches
- 8 to 16 inches

We sampled leaf petioles and blades at three times to determine nutrient concentrations:

- At bloom
- Thirty days after bloom
- At veraison

We determined yield per vine and mean cluster size and collected berry clusters to measure four juice variables:

- Sugar concentration (˚Brix)
- Yeast assimilable nitrogen (YAN) concentration
- pH
- Titratable acidity (TA)

Methods:

In the spring of 2012, from each replicate, soil cores were collected at depths of 0-8 and 8-16 inches, dried, and sent to Agvise Laboratories (Benson, MN) for analysis.

In 2012 and 2013, leaves were collected at bloom, 30 days after, and at veraison. The leaves were separated into petioles and blades, dried, and sent to Agvise Laboratories for nutrient analysis.

In both years, yield per vine and mean cluster size were determined for a sample of vines at the harvest time determined by the grower. At the same time, a sample of grape clusters was sent to the University of Minnesota Horticultural Research Center and analyzed for ˚Brix, YAN, pH, and TA.

No new data were collected in 2014. Analysis of data collected in 2012 and 2013 is ongoing, and complete results will not be presented until the 2015 data have been collected and included in the analysis. Preliminary results are presented.

Multiple regression analyses were performed for each yield or juice variable. The soil and tissue variables were divided into 8 groups: soil variables at each depth (2 groups) and tissue variables for each tissue at each sampling time (2 tissues X 3 collection times = 6 groups). A separate multiple regression was performed for each dependent variable against each group of independent variables. Results for whole leaves closely paralleled the results for leaf blades and are therefore not presented.

The analyzed data were purged of outliers, defined as points lying more than three interquartile ranges (IQR = the third quartile minus the first) above the third quartile or below the first. The vast majority of outliers were at the high end. Separate analyses were performed on data that included all outliers and data that excluded only outlier values that were either exceptional for their site and cultivar or clearly attributable to applications of Bourdeaux mix. However, the results of those analyses have not been tabulated.

Within some of the groups of independent variables, pairs of variables were strongly correlated ($R > 0.8$: soil Ca and CEC; soil texture variables; blade N and S 30 days after bloom). In those cases, the regression was repeated with the correlated variables replaced by a principle component to assess whether the apparent statistical significance of those variables was influenced by their covariation.

Additionally, because dependent variables were collected under non-ideal conditions in some cases (e.g., yield depressed by heavy bird predation; juice data obtained from must instead of fresh berries), analyses were performed both with and without data from those cases.

Regressions were performed in SAS 9.4 using the GLM procedure, with year, cultivar, and site included in each model. This approach was used to identify soil and tissue variables that significantly impact yield and juice characteristics across years, cultivars, and sites, thus limiting the presented results to strong effects, in keeping with the preliminary nature of the data.

Results:

Only results that are consistent and significant at $\alpha = 0.05$ across all models are presented (Table 1).

What the results mean:

- High tissue N was associated with high yield per vine and high cluster size.
- YAN increased with increasing soil and tissue N.
- High tissue K was related to higher juice pH.
- Vines with higher tissue calcium tended to have higher yield per vine.
- High tissue S corresponds to decreased juice sugar content.
- Tissue variables were much more likely to be significantly associated with yield and juice variables than soil variables were.

Table 1. Directions (+ or -) of significant relationships between yield and juice characteristics and soil and plant tissue nutrient concentrations, averaged over cultivar and year, based on multiple regression analyses.

Dependent variable	Sample type	Soil depth or tissue type	Nutrient											
			N	P	K	S	Ca	Mg	Na	Zn	Fe	Mn	Cu	B
Yield/vine	Tissue at bloom	Blades	+		+		+							
		Petioles											-	
	Tissue 30 days after bloom	Blades	+				+	-						
		Petioles					+		-					
	Tissue at veraison	Blades							-					
		Petioles	+				+							-
Yield/cluster	Tissue at bloom	Blades	+											+
	Tissue 30 days after bloom	Blades	+					-						
		Petioles				+				-				
	Tissue at veraison	Blades	+									+	-	
		Petioles	+				+						-	
Brix	Tissue at bloom	Blades				-								
		Petioles				-				+		+	+	
	Tissue 30 days after bloom	Blades	-			-								
	Tissue at veraison	Blades			-								-	
pH	Tissue at bloom	Blades		+			-							
		Petioles			+								+	
	Tissue 30 days after bloom	Blades			+									
		Petioles			+	+						-	-	
	Tissue at veraison	Blades	+		+	-								+
TA	Tissue at bloom	Blades												
		Petioles	+			+				-				
	Tissue 30 days after bloom	Blades											+	
		Petioles		-		-						+	+	
	Tissue at veraison	Blades			-			-	-					
		Petioles		-								+		
YAN	Soil	0 - 8 inches									+			
		8 - 16 inches	+							+				
	Tissue at bloom	Blades	+		-									
		Petioles						+			-			
	Tissue 30 days after bloom	Petioles				+							-	+
	Tissue at veraison	Blades	+							-				
		Petioles	+											