GRAPE JUICE INDICATORS FOR PREDICTION OF POTENTIAL WINE QUALITY. I. RELATIONSHIP BETWEEN CROP LEVEL, JUICE AND WINE COMPOSITION, AND WINE SENSORY RATINGS AND SCORES

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ABSTRACT

The good wine-aroma intensity of wine from Zinfandel grapes was correlated with crop level and several of the juice components. Selected as the most practical indicator of aroma intensity (r = +0.800) was °Brix × pH. The ratios of the acetate esters to corresponding alcohol also correlated with the aroma ratings. The °Brix × pH also correlated well with the flavor intensity rating (r = +0.836), which in turn correlated with crop level. Many correlations were calculated between crop level and other variables. The overall sensory scores could not be correlated significantly with crop level, °Brix × pH or any number of variables. A possible explanation is given.

Commercial payment for grapes is usually based on °Brix alone. Most wineries require a minimum level of sugar, and some pay bonuses for grapes of higher °Brix. According to Winkler (12) overcropping of grapevines will cause delayed maturity and lower titratable acidity and color. Amerine and Winkler (1) suggested °Brix/acid ratio as an analytical measure of overcropping. Ough and Singleton (10) showed that °Brix/acid ratios could be related to wine quality. The crop level was constant in their studies, and the fruit maturity was varied. Loinger and Safran (8) found no effect on commercial wine quality in investigations of a number of variables including crop level.

This study investigates some of the possible juice variables which can be used to relate crop level to the sensory quality of the resulting wine.

MATERIALS AND METHODS

Grapes: The grapes came from a commercial vineyard in the Lodi district of California, where the Zinfandel grape is an accepted variety. The area is medium warm and the vintage was normal. Crop level was adjusted by five different treatments of pruning, flower cluster thinning, and gibberellic acid treatment. The treatments were: A) heavy crop, 12 spurs, no thinning; B) medium crop, 12 spurs, flower cluster thinning; C) medium crop, 8 spurs, no thinning; D) low crop, 8 spurs, 5 mg/l of gibberellic acid/acre; and E) low crop, 8 spurs, flower thinning. All fruit was harvested between 20.7°Brix and 24.6°Brix from September 10 to September 24. The yields ranged from 4.8 to 14.6 tons/acre on this vineyard, which was normally cropped to 9 tons/acre. Six field replicates of five vines each were harvested for each treatment.

Wines: The grapes were harvested and transported to the University cellar at Davis. They were crushed and sampled immediately, SO_2 was added, and they were fermented at 21°C with *Saccharomyces cerevisiae* strain Montrachet. At about 5°Brix the wines were pressed and finished. None of the wine developed malo-lactic fermentations or hydrogen sulfide before analysis and sensory evaluations were completed.

Analyses: Routine chemical analyses were done as described by Amerine and Ough (2). The headspace analyses for esters and alcohols were done by the method of Jennings et al. (6). Internal standards used were 3-pentanol and n-octanol. The trapping system was Porapak Q., and separation of the volatile concentrate was on a 30-meter 0.25-mm-I.D. open tubular glass capillary column mounted in a Hewlett-Packard

5720A gas chromatograph. An 80:1 split was achieved with a pre-column all-glass splitter. The column was programed from 65°C to 180°C at 1°C/min. The peaks were identified by mass spectra, Kovats indices, and relative retention times.

Sensory evaluation: The wines were evaluated by an expert panel of 12 trained tasters. Good wine-aroma intensity, flavor intensity, and wine balance were rated on a scale of 1-10. Overall wine quality was determined on the Davis 20-point score card. Every wine was judged twice by each taster for each test.

Statistical treatment: Analysis of variance and linear and second-degree polynomial regression analyses were used to determine differences between treatments and to determine correlation between variables and between treatments and variables. All data were analyzed on the Burroughs 7600 computer.

RESULTS AND DISCUSSION

Significant variations in crop loads resulted from the treatments. These data are summarized below:

	Treatment				
	A	B	C	E	D
Crop lb/vine	53.6	39.3	38.0[1]	31.0	23.3

Least-significant difference 0.05 = 5.8 lb/vine.
[1] Values underlined by same line not significantly different.

The six replicates for each treatment were fermented separately and used for further correlation studies.

A primary consideration was to determine whether judges could differentiate the wines made from these treatments. Analyses of variance for the good wine-aroma and taste-intensity ratings indicated that the treatment mean values could be separated at the 1% level of significance. The individual good wine-aroma ratings and intensity-of-flavor ratings were both correlated with crop level values, respectively Figs. 1 and 2. Both show a significant negative correlation to cropping level.

Table 1 gives the correlation data for the various juice analyses to the crop levels. The best crop-level correlation was with pH, followed closely by Brix x pH and total nitrogen. These data are graphed in Fig. 3 (pH), Fig. 4 (Brix x pH), and Fig. 5 (total nitrogen). The °Brix x pH was selected for further treatment. It incorporates factors of general importance. The °Brix is an essential consideration. It determines the amount of alcohol, which is important for economic and for sensory value. It reflects to a certain degree the accumulated effect of leaf photosynthesis. The pH indicates changes in the ionic makeup of the grape. As buffering materials, such as amino acids, move into the vine, pH can change. Also, as the potassium from the soil is transferred to the grape, pH is affected through changes in the tartrate ionization. Delayed harvest causes losses in malic acid; hence, a change in pH. Others (7) have suggested that pH be used as a criterion for grape maturity from warm regions.

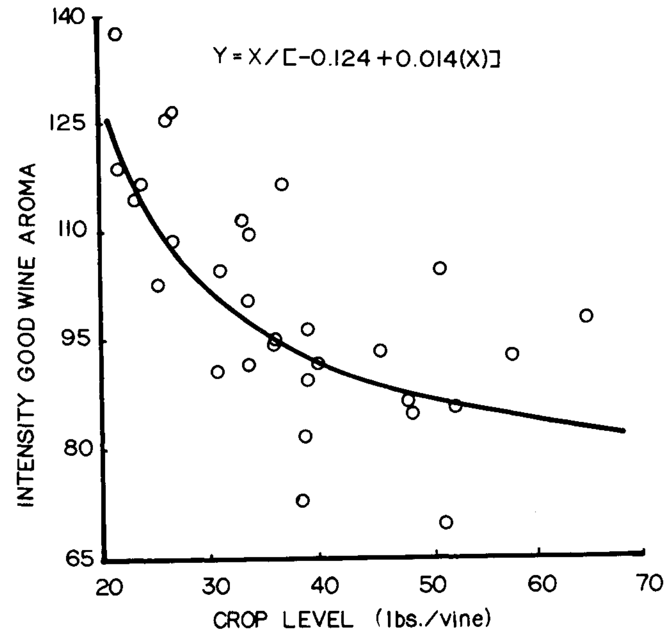

Fig. 1. Relationship of crop level to good wine-aroma intensity ratings.

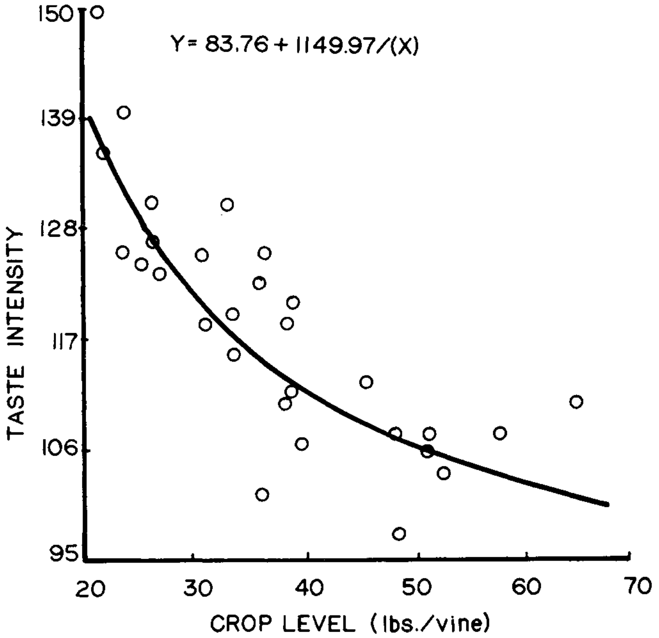

Fig. 2. Relationship of crop level to taste intensity ratings.

The most striking find from the headspace analyses was the decrease in secondary alcohols and increase in the corresponding acetate esters with decreasing crop level. Table 2 gives the concentration ratios of the acetate esters to corresponding alcohol for four alcohols in the five treatments. Table 3 shows the correlation statistics of these values to the good wine-aroma values. Reasons for the changes in those components are available in the literature. Nordstrom (9) showed that increased nitrogen levels caused increased ester formation. The greater amounts of acetyl CoA formed by a bigger yeast population caused increased ester

Table 1. Correlation coefficients for various juice measurements to crop level.

Analyses	Correlation coefficient r[a]	Coefficient of determination R^2
°Brix	−.819	.670
pH	−.918	.843
Total nitrogen	−.088	.774
Total phenol	−.719	.517
°Brix x pH	−.902	.814
°Brix/total acidity	+.343	.118

[a] n = 30.

Table 2. Acetate ester/alcohol ratios as they vary with the five treatments.

Acetate ester/alcohol	Treatments				
	A	B	C	D	E
n-Propyl/n-propanol	.029	.038	.025	.097	.061
Isobutyl/isobutanol	.053	.075	.041	.114	.079
Isoamyl/isoamyl alcohol	.293	.376	.254	.717	.506
n-Hexyl/n-hexanol	1.175	1.506	.932	2.520	2.075

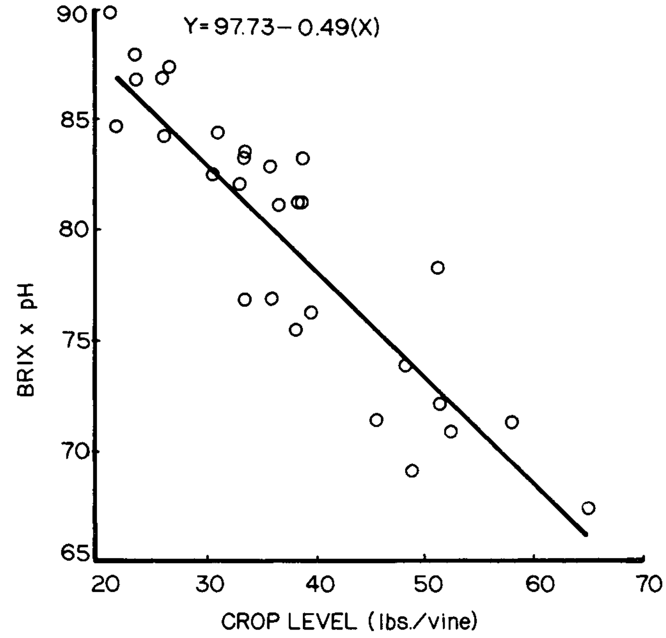

Fig. 4. Relationship of crop level to juice °Brix x pH.

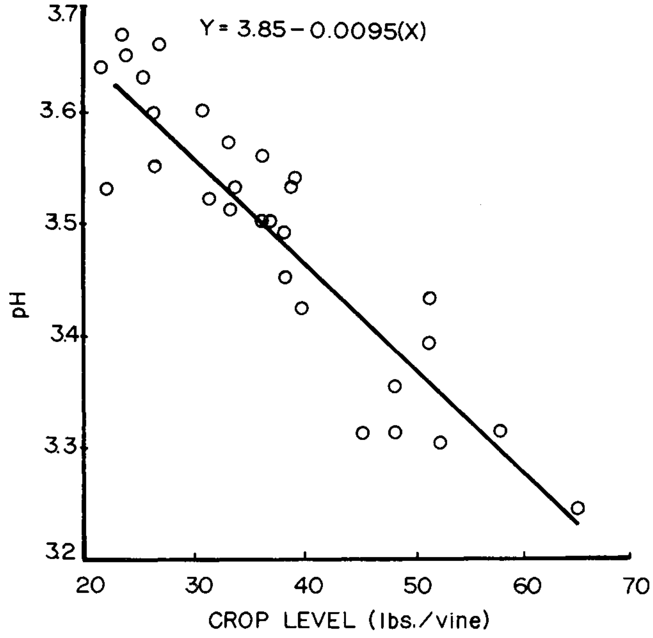

Fig. 3. Relationship of crop level to juice pH.

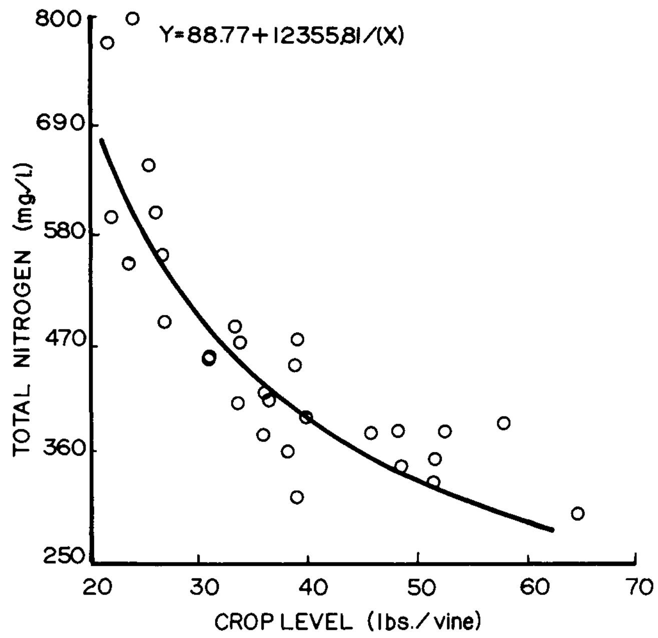

Fig. 5. Relationship of crop level to juice total nitrogen.

synthesis. Engan (5), on the other hand, believes that nitrogen plays a minor role, with °Brix more important. Anderson and Kirsop (3) also indicate that both °Brix and nitrogen contribute positively. The secondary alcohol contents are affected by nitrogen content. Ayrapaa (4) has shown during fermentation that higher nitrogen levels decreased the biosynthesis of isobutyl, isoamyl, and active amyl alcohols. The hexyl alcohol is produced primarily in the grape and is not greatly altered during fermentation. Those summations agree with the findings here. What can be concluded is that the lower-crop vines with higher nitrogen (and increased °Brix) can be expected to result in wines with higher acetate esters and lower secondary alcohols and therefore contribute more intense wine-aroma than heavier-cropped vines. Wagener and Wagener (11) showed that the acetate esters contributed to wine quality. Fig. 6 plots the n-hexyl acetate/n-hexyl alcohol versus the good wine-aroma intensity ratings.

A number of correlations were made between the taste intensity ratings and the juice analysis (Table 4). Total nitrogen gave the best results, with Brix x pH a

Table 3. Correlation of acetate ester/alcohol ratios to the intensity of good wine-aroma.

Statistic	Acetate ester/corresponding alcohol			
	n-Propyl	Isobutyl	Isoamyl	n-Hexyl
Correlation coefficient r[a]	.699	.776	.820	.820
Coefficient of determination R^2	.489	.602	.672	.676

[a] n = 30.

Table 4. Correlation of various juice analyses to taste intensity rating.

Statistic	°Brix	Brix x pH	Brix/ acidity	pH	Total nitrogen	Total phenol
Correlation coefficient r[a]	.779	.836	.312	.722	.866	.538
Coefficient of determination R^2	.607	.699	.097	.522	.750	.289

[a] n = 30.

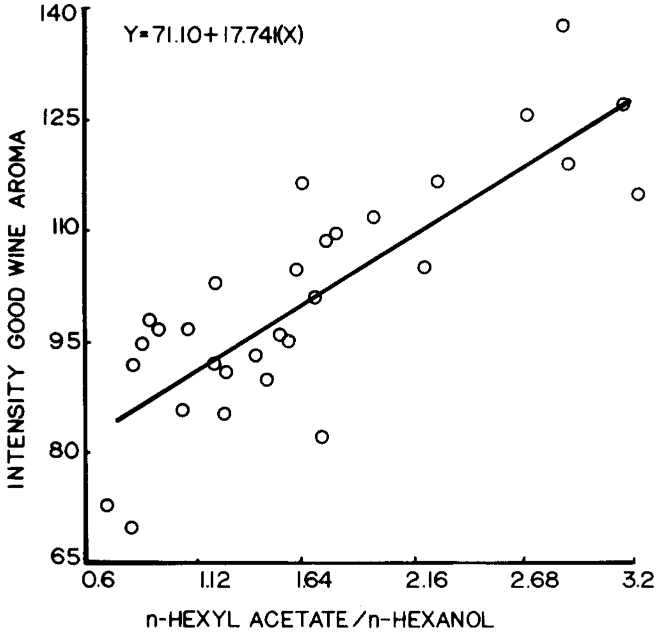

Fig. 6. Relationship of n-hexyl acetate/n-hexanol wine values to good wine-aroma intensity ratings.

close second. Fig. 7 plots total nitrogen versus taste intensity. The taste intensity did not specify good or bad tastes, just the intensity. Neither the variations in pH, titratable acidity, or total phenol can explain the changes in taste intensity. Certainly the total nitrogen increase *per se* does not cause it. It is probably associated with ionized material and body in the wine and other changes affecting the taste senses. Also, it is unlikely that the judges could completely ignore the aroma of the wines even though they were so instructed.

Table 5 summarizes the correlations of °Brix x pH with the variables studied and not listed previously.

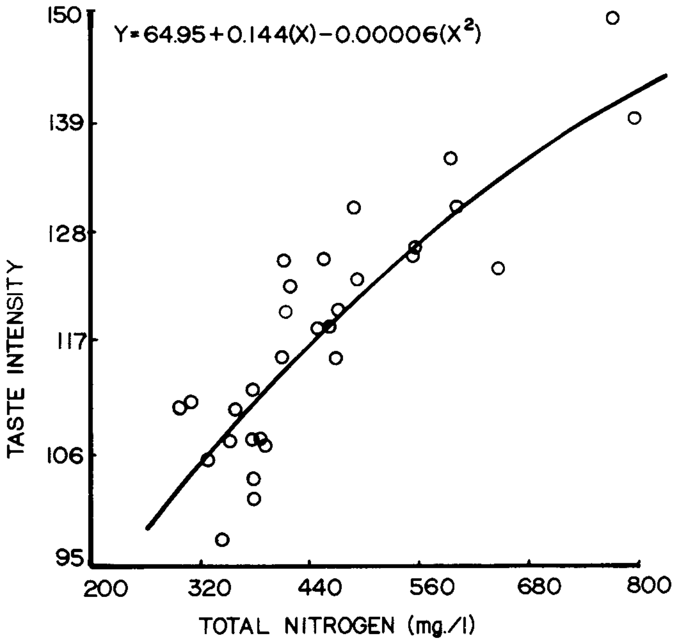

Fig. 7. Relationship of juice total nitrogen to wine taste intensity ratings.

Table 5. Correlation of Brix x pH juice measurement to various juice and wine components and to the sensory ratings and scores.

Variable	Correlation coefficient r[a]	Coefficient of determination R^2
Total nitrogen	.815	.665
Total phenol	.755	.571
Total phenol (excluding treatment D)	.913	.833
n-Propyl acetate/n-propanol	.648	.420
Isobutyl acetate/isobutanol	.708	.502
Isoamyl acetate/isoamyl alcohol	.770	.593
n-Hexyl acetate/n-hexanol	.847	.718
Taste intensity	.836	.699
Good wine-aroma intensity	.800	.641
Balance (rating)	.445	.198
Quality (20-point score card)	.165	.027

[a] n = 30.

The relationship of Brix x pH to total phenols (Fig. 8) is excellent if the gibberellic acid treatment data are excluded. The lower amounts of total phenol produced in wines treated with gibberellic acid cannot be explained on the basis of our data, but may be due to a reduction in seediness often noted with use of this chemical. Additional work should be done.

Of further interest are the balance ratings and the overall sensory scores. The panel, evidently having mixed thoughts on what constituted a balanced wine, could not rate the wines significantly. The quality scores did not correlate significantly with °Brix, pH or with other variables or crop level. Analysis of variance gave no significant treatment effect. Several reasons can be offered. First, the Davis scorecard is unreliable for wines that are similar. Second, wines from the low-crop grapes had better aroma characteristics, but the intensity of taste counteracted those good attributes.

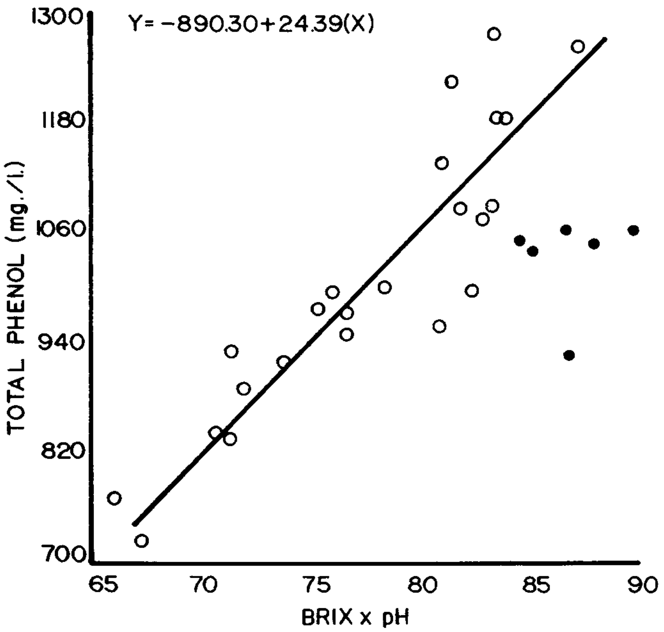

Fig. 8. Relationship of juice Brix x pH to juice wine total phenol. ● gibberellic acid treatment, ○ other crop-level treatments.

Wines from the higher-cropped vines had a less pleasing aroma but a more acceptable taste, and the medium-crop wines were medium in both factors. It is possible that the wines with the more intense tastes might excel in quality if aged for a period, with the flavors becoming modified. Basically, the low-cropped fruit has more potential than the overcropped fruit.

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