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Some Viticultural Limitations in some of Oregon Viticulture:

An Integrated Approach to their Local Identification and Viticulture Management Responses to Them

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Introduction

This presentation and the 1986 visit to Oregon were by invitation from Oregon State University and the Wine Advisory Board, and supported by the Sokol Foundation. The ideal cooperation of Professor Porter Lombard and Mr. Steve Price is most gratefully acknowledged. We were in a learning experience, and humble in the complexities of grapevine growth and fruiting.

My very limited experience in the viticulture of your region includes, in 1950, a sabbatic leave of six months for grape research with Dr. Walter Clore in Prosser, Washington. I've been involved in the cool climate viticulture of New York since 1944.

This paper will emphasize the integrative nature of these three groups of elements in the soil-canopy-grape complex:

1. Site, soil, and vineyard characteristics with those of;
2. Vine, rooting, and canopy with;
3. Grape composition and grape yield.

That integrative nature affords the opportunity to examine some elements of each of these three, as they may limit the attainment of the goals of grape composition and yield. As a part of a specific vineyard, one can examine those elements by description and diagnosis, then select the practice(s) to reduce the limitation. That approach, containing very much that is routine with good management, emphasizes both a systematic approach to the above three groups of elements and an orientation to limitations rather than to practices. For example, Table 1 shows, for one Concord vineyard, the integration of top soil depth with the amount of nitrogen, and of available water, with vine size which affects the yield for balance-pruned vines.

Table 1. Surface soil depth^z effect on soil water and nitrogen, vine size^y and yield^x of "Concord" in a Pennsylvania vineyard. Row \times Vine = 2.7 \times 2.4^m, 1948. Adapted from Alderfer and Fleming [3].

	Relative values at various depths as percent of 21.6 cm soil depth					Absolute Values at 21.6 cm soil depth
	Depths (cm)	14.0	16.5	19.0	21.6	
Available water	72	90	90	100	125	53 mm
Soil Nitrogen	58	75	82	100	113	3,430 kg/ha
Vine size (wt. prunings)	45	82	82	100	113	1.0 kg/vine
Grape yield (wt. prunings)	63	89	91	100	105	5.7 kg/vine

^z Variable depth by soil erosion and deposition; rooting depth to 1.8m; soil, Chenango gravelly sandy loam, 6m deep.

^y Cane prunings.

^x Balance pruned.

Observations on Limitations in Oregon Viticulture

Adelsheim (1) recognized that lack of sunlight was limiting; that erosion was a problem; and described an ideal vertical canopy which would avoid the limitations of a canopy density that was too low, or that was excessive because it caused too much shade. Adelsheim (2) recognized that growing season heat was limiting in western Oregon; and that slow development of vines was costly. Lombard (4) discussed limiting factors, problem identification and corrections, the components of grape yield per node, as well as grape soundness and grape maturity.

Limitations in Viticulture

Definition. A limitation is any part of the viticultural enterprise which adversely affects:

- 1) The yield of sound, ripe, grapes of the desired variety/unit area of land/decade; and
- 2) The cost of production and harvesting per ton of such grapes.

Because limitations are likely in every viticultural enterprise, viticulture might be defined as the continuing effort to identify, understand, avoid, prevent, and/or correct the limitations to the most efficient production of sound, ripe grapes of the desired variety. Here, the definition of soundness and ripeness depends on the use of the grapes; for wine grapes, it is defined by the winemaker. Efficient production is measured by the long-term cost per ton of sound, ripe grapes.

Examples. Table 2 is a list of only some of the limitations to the efficient production of sound, ripe grapes. it is constructed with vineyard location (items 16, 17, 18) as the base which supports the grape vine (items 4 through 15), from which is obtained the grape crops (items 1, 2, and 3).

Table 2. Some limitations to the efficient production of ripe grapes of a desired variety associated² with weather and with viticultural decisions.

Limitations	Association with (*)		
	Weather	Decisions at Pre-Planting	Post-Planting
<u>Grape Crop</u>			
1. Non-soundness (as pests, hail)	*		*
2. Non-desired composition	*	*	*
3. Non-desired yield level	*	*	*
<u>Grape Vine</u>			
<u>Canopy</u>			
Leaf non-soundness			
4. Pests	*		*
5. Air pollution: phenoxy compounds		*	
6. ozone excess		*	
7. Shade-induced senescence		*	*
8. Nutrient-related	*	*	*
9. Delay, years, to developed-vine size		*	*
10. Length per acre, inadequate spacing		*	*
11. Density, too sparse or too dense		*	*
12. Size, as height of canopy ³		*	*
<u>Root Environment</u>			
13. Water, deficit or excess	*	*	*
14. Pests, including weeds		*	* ^x
15. Nutrients, deficient or excessive	*	*	*
<u>Vineyard and Location</u>			
16. Regional hazards of freezes, rain, summer heat, air pollution, and wind	*	*	
17. Topography-induced hazards of freeze and erosion		*	*
18. Soil depth, inadequate		*	

² For example, a water deficit, line 13, is associated with weather; with pre-planting decisions re soil depth and texture, runoff control by row direction; and with post-planting decisions as irrigation and soil management.

³ Canopy height may be more or less than trellis height.

^x Root pests, as phylloxera, excluded.

This partial list of enterprise limitations recognizes not only the soil-canopy-grape complex, but also the association of elements of that complex with weather, pre-planting decisions, and post-planting decisions. The pre-planting decisions regarding soil depth, regional hazards including air pollution by phenoxy compounds, rootstocks, and virus status are not subject to post-planting change by the vineyardist. Post-planting decisions include soil management and fertilization; training, pruning, crop control, canopy management; and pest control by pesticides. This very broad approach is essential because each limitation can be damaging. Being aware of that can put the emphasis on avoidance, or on prevention of the limitation, rather than being faced with a limitation which is difficult, or impossible to correct.

Interactions and associations. This very broad approach recognizes that the limitations are not independent of each other. In fact, the association between some of them is close. For example, the association of soil depth with water adequacy (for non-irrigated vineyards in a lowrainfall period) with a canopy density is common. Another example is the association of vineyard topography (on the formation of eroded knolls) with the lack of adequate nutrients (such as nitrogen, potassium, or boron) with the leaf soundness and canopy density. A third example is that of excessive crop (on a developing or too-small vine) which can lead to one or more years delay until the transition from developing vine to developed vine. The vine status is measured by the weight of cane prunings per vine per unit length of canopy.

Significance of uneven distribution. Within a vineyard, a limitation may be distributed uniformly, as

inadequate length of canopy per unit area of land, or not uniformly. There are numerous examples of non-uniformly distributed limitations. They can be between areas within a vineyard as in Table 1; or between vines or even within a vine, such as differences in canopy density and grape composition.

Uneven distribution of limitations has been determined by many measurements, such as vine size (the weight of cane prunings per vine at uniform within-row spacing), node number retained per vine, grape yield per vine, and some measures of grape composition. The decisionmaking for a vineyard could be improved by knowing both the vine size desired and the range in vine size. Then, one knows more about the extent to which vine size, or canopy length per vine, should be increased or decreased. If by knowing, in addition, the range in node number retained, the range in grape yield per vine, and the °Brix, one knows to what extent the pruning and crop control met the desired goals of grape composition and yield. Such information obtained on a sample of vines in that vineyard could indicate both the extent of some important limitations, and their distribution within the vineyard.

The significance of uneven distribution of canopy attributes is evidenced in the difference between the exposed canopy exterior and the shaded canopy interior. The inferiority of the interior canopy has many expressions in shoots, buds, leaves, and grape production and composition, as we have reported in 1966 (7), 1969 (9), 1974 (8), and 1980 (6). Many have reported on those relationships, or recognized them, including Adelsheim (1).

Where the limitation can be improved, and is unevenly distributed, the corrective action should be applied in proportion to the severity of the limitation. That is the procedure with such obvious problems as trellis wires or posts that are broken or weak. The suggestion here is that analysis of the distribution of limitations can be effectively applied to management of vineyard soils, vine canopies, and grape crops and become a basis for the management of the soil-canopy-grape complex.

Viticultural Approaches to Viticultural Limitations

Pre-planting decisions emphasize the avoidance and prevention of limitations. For one vineyard, the approaches to the viticultural limitations, can include a broad spectrum which ranges from:

1. 1) Withdrawal from the enterprise; to
2. A least-cost approach, which nearly ignores viticultural limitations, while emphasizing minimum cost per year per unit area of land; to
3. A general approach which, aware of some limitations, emphasizes the efficient and uniform application of practices (either recommended or of tradition) which are generally aimed at preventing or correcting a limitation; to
4. A more specific approach, a) which recognizes that some pest control practices recommended to prevent limitations should be generally applied, b) emphasizes the identification of specific viticultural limitations, c) analyzes the distribution of limitations within the vineyard, d) diagnoses the causes of the limitations, e) selects an appropriate practice to eliminate or reduce the limitation, and f) applies the practice in response to the severity of the limitation. This specific approach to viticultural limitations is based on the process of description-diagnosis-prescription. Table 3 affords more detail on that approach.

Table 3. A descriptive-diagnostic-prescriptive approach for viticultural limitations to the most efficient production of grapes of the desired composition.

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1. Descriptions of vineyard², vine³, and crop⁴ limitations and the distribution of each, plus
 2. Diagnosis of each limitation, plus
 3. Prescription of optional practices and site(s) of application for each limitation, plus
 4. Management's choice of option, and its application in response to the severity of the limitation.
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² As in Univ. of California Div. of Agric. Sci. Leaflet 2946 p. 20(5).

³ Description includes observations, measurements, counts, and chemical analyses of petioles, grapes, and soil.

⁴ Includes abnormal size of cluster and berry, soundness, time of veraison, and °Brix.

Depending on the severity of the limitations, the resources available, or the experience of the manager, one of the first three approaches could be appropriate. Although elements of the fourth or specific approach, such as balanced pruning and fertilization based on petiole analyses and soils tests, have been applied extensively and usefully, its systematic application has not been extensive, but has been very useful.

These are not four distinct approaches. For instance, using the more specific approach of description-diagnosis-prescription has led, in a few cases, but not in Oregon, to the prescription to withdraw from the enterprise. That specific approach also has led to a prescription to use less nitrogen and to use less potassium, not to reduce costs, but to prevent an increase in the limitation of an excessively dense canopy or to avoid the limitation of a potassium-induced magnesium deficiency.

General approaches. Such approaches emphasize the selection and use of uniform viticultural practices in the management of soil, canopy, and grapes. There is much less emphasis on defining the limitations within each vineyard. The approach is attractive because, 1) it allows for general recommendations, 2) the applications become familiar with repeated use, and 3) decision making is simplified.

General approaches, as described, may be incomplete because the desired match of the selected practices with the actual limitations may or may not be achieved. Practices may be applied after the limitation has been corrected; or there may be unrecognized limitations for which generally applied preventative or corrective practices were inadequate. Within a row of grapevines, there can be desired responses to application of mulch or potassium or to crop thinning on small vines on eroded knolls, with no response, or a negative one, by large vines in swales. With high variability in the severity of a limitation either between vineyards or within a vineyard, a uniform application of a corrective practice is likely not to be the optimum application.

A specific approach. In a very general manner, this approach is outlined in Table 3.

Vineyard description. An appropriate time for the description is during the season when important limitations are first or best displayed. Examples are: late winter for freeze damage; after fruit set for fruit set problems; or at veraison for a broad examination of the soil-canopy-grape complex.

The vineyard or unit of vineyard chosen for description should be uniform in variety, state of vine size development (as developing or developed), vine training, and spacing of rows and vines. The unit should not be substantially dissimilar in water supply (as soil depth or irrigation), or in drainage of soil water and cold air, or in soil erosion or deposition. Finally, the unit should be large enough to manage.

A description of a vineyard would include a list of general characteristics, as indicated by Table 2. Additional characteristics may be necessary to describe a particular situation. A list of items to describe

a particular vineyard is a readily-amended tool for describing that vineyard. Because many of the limitations listed in Table 2 are of general categories, such as pests, composition, yield, and nutrients, it is necessary to expand each of those to the specific pest, chemical component, element of yield, or the specific nutrient relevant to the chosen vineyard. Based on the 1972-1986 experience, a rigid list, fixed by prior successful use, cannot respond to changing limitations, and loses some of its usefulness.

The description is by counting and measuring, where possible, and by estimation and observation of characteristics. This is done along the full length of an indicated pair of rows, with separate observations made for "eroded knolls", or a major change in slope, which affects canopy density. Depending on the size of the vineyard (up to about 6 ha) and its heterogeneity, two to five pairs of rows are separately described. The descriptions are very brief, either numerical counts or measurements, or values on an arbitrary scale. Such a scale, as 0 to 20, with 10 as the desired value, has been useful for evaluating crop load or nitrogen adequacy. The description is better when using objective data such as:

- Weight of cane prunings per vine, **re** vine size and canopy density.
- Number of nodes retained at pruning, and pruning weights per vine. Analyses of petioles, **re** mineral nutrient adequacy.
- Analyses of surface soil and subsoil, **re** adequacy of nutrients in the soil.
- Depth of soil, and vine root development; identification of soil series; and root soundness from one or more soil trenches, according to Neja, et al. (5).
- Fruit composition, and yield.

The cost of such information is known and can be acceptably low, if one chooses to know more about the vineyard, vines, and crop. The cost of not having the information is an unknown, but very likely it is more than zero.

Diagnosis. The diagnosis of a described characteristic can be difficult. It is based on; 1) the extent to which the characteristic is outside of the desired range of values for that characteristic; 2) the importance of that deviation from the desired range; and 3) the causes of that deviation. For some characteristics, the desired range of values is not yet known; and tentative estimates need to be made between levels of serious inadequacy and of serious excess. There are three important questions. 1) What are the goals for grape composition and grape yield? 2) What is the range of canopy attributes and of crop characteristics which best attain those crop goals? 3) What is the range of soil and site attributes which most rapidly produce and maintain those canopy attributes? That complex of soil-canopy-grape is not adequately understood, nor completely defined, and it is variable with respect to grape variety and use, and to environment. But it is understood and defined at a level which at least identifies the extremes, and so is useful in the diagnosis of vineyard, vine, and grape description.

Defining that complex of soil-canopy-grape is a major goal of research in viticulture and enology. Familiarity with research that has contributed, and that which now contributes, to that definition is very useful in diagnosis.

As an example, Table 4 is based on Concord grape vines in New York. These 1957 data were first published in 1966 (7), and used in a review in 1980 (6). The original vines, prior to the treatments, were equal in spacing of rows and vines, vine size, and nearly equal in the yield (low) per vine and leaf area (adequate) per vine. By shortening the canopy length, the canopy density was increased from 0.4 to 0.75 and to 1.5 kg cane prunings per meter of canopy, which caused a slower rate of sugar accumulation in the berries. Such information is helpful in the diagnosis of the canopy length, canopy density, and crop load characteristics of the described vineyard.

Table 4. Effect of canopy density changes by controlled length of canopy, on °Brix and crop efficiency of Concord grapes 1957. Row × Vine × Ht. = 2.4 × 2.4 × 1.8m. 0.9 kg cane prunings per vine. Adapted from Shaulis (6).

Canopy Length (m)	Crop Yield (kg/vine)	Canopy Density			°Brix		(kg crop/kg prunings)
		Leaf area (m ² /m row)	Cane prunings (kg/m row)	Leaf Area (m ² /m ² of trellis)	Sept. 9	Oct. 21	
0.6	3.9	10.5	1.5	4.8	12.2	17.3	4.3
1.2	4.5	6.7	0.75	3.0	13.2	17.6	5.0
2.4	4.1	3.5	0.4	1.6	13.8	18.4	4.6
3.6	4.1	2.0	0.25	1.0	14.3	18.4	4.6

The diagnosis of a characteristic requires knowledge of the range of values of those characteristics which are limiting; and it requires a knowledge of the relation it has to other characteristics. An example could be a canopy density which is too low. The problem is to identify the more important causes, such as the limitation of in-row spacing, water, root pests, weeds, erosion, nitrogen, pruning severity, crop load, and/or pests.

Diagnosis may not be possible without more description or assistance by a specialist. Diagnosis may also identify some extremely serious limitation, about which little can be done by the vineyardist, such as very shallow soil, root pests which cannot be controlled by pesticides, or regional air pollution.

Prescription. Finally, with the description and diagnosis, comes the less difficult listing of practices applicable to the limitations indicated by the diagnosis, and the choice of, and application of, the selected practice(s). Table 5 indicates some of the means by which some characteristics of the canopy can be modified. Similar or expanded lists of means of modifying the characteristics of grape crop and of soil could be made. These help to include the practices which can most effectively reduce or eliminate the limitations brought into focus by the description and diagnosis of the vineyard and vine characteristics.

Table 5. Some viticultural means of affecting canopy characteristics. Adapted from Shaulis (6).

Means of affecting canopy attributes	Canopy Characteristic Affected (*)					
	Length per unit area land	Spacing between canopies	Density or spacing in canopy	Ht.	Width	Roughness
Row spacing	*	*				
Canopy division	*	*	*			
Vine size [‡]		*	*		*	
Vine spacing			*			
Canopy length/vine [‡]			*		*	
Trellis height			*	*	*	
Cane length [‡]			*	*	*	
Renewal area ht.			*	*		
Shoot positioning			*		*	*
Pruning severity			*			
Summer pruning			*		*	*

[‡] Includes practices re water, nitrogen, crop load, and pests.

[‡] When less than in-row spacing of vines; or to achieve double the in-row spacing of vines.

[‡] For non-horizontal canes.

The weaknesses of this specific approach are the:

- Variability, even within the unit selected for uniformity;
- Difficulty in accurately describing a characteristic;
- The many voids in the diagnostic effort;

- d) The uncertainty in the prescriptions; and
- e) The extra effort required for specific application of the practice to less than the entire vineyard.

These weaknesses can be reduced by your greater familiarity with the characteristics of your vineyards and vines and the grape responses thereto, as well as with published results in viticulture and by asking specialists. Encouraging research that helps to define the characteristics of the soil-canopy-grape complex desirable for specific goals in grape production can contribute to both diagnosis and description.

The gain is an increased awareness of the variability between vineyards and within a vineyard; and an increased awareness of the many limitations on the soil-canopy-grape complex, and the relation of and application of viticultural practices to reduce those limitations.

Summary and Conclusions

The description-diagnosis-prescription approach to the management of vineyards and vines is outlined.

Descriptions and diagnoses lead to awareness of the limitations in the soil-canopy-grape complex. Prescription, of viticultural practice(s), makes viticultural management more oriented to the avoidance, prevention, and correction of the limitations. This approach, of description-diagnosis-prescription, can help to achieve the goal of efficient production of grapes of the desired variety, desired composition, and desired yield.

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