INTERNATIONAL JOURNAL OF AGRICULTURAL SUSTAINABILITY
1473-5903/03/02 0089-06 $20.00/0
Vol. 1, No. 2, 2003

Sunburn on the Vineyard: Terroir and the Sustainability of Juice Grapes in an Arid Climate

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Agricultural sustainability practices make the best use of both nature's resources and available technology, and generally avoid those land use practices that lead to greater environmental stress. There are examples in some agro-ecosystems, however, where stress is vital to food quality and productivity. In the case of grape production, a limited amount of environmental stress actually leads to an increase in fruit quality, and with wine grapes, to improved wine quality. But when the stress exceeds an acceptable threshold, vine vigour declines and production and quality may be compromised. Using our experiences with environmental stress in grapes grown in the landscapes of Central and Eastern Washington, USA, we question how agricultural sustainability should consider environmental stress, and at what point management interventions contribute or detract from a sustainable system. Framed by the two French land-related terms 'appellation' and 'terroir', we discuss agricultural sustainability for grape cultivation in an arid climate.

Keywords: appellation, environment stress, grapes, landscape sustainability, management adaptations, terroir, vineyard

Introduction

The production of wine and juice grapes in the Columbia Valley of Washington, USA presents some interesting questions regarding agricultural or landscape sustainability. In the valley, some environmental stress (high radiation and water deficit) is desirable for fruit quality, if that stress can be kept within limits. Irrigation schemes that allow growers to determine when and how much water is applied to an orchard are relatively high input practices, especially in a climate where water is limited. Yet by moderating environmental stress with water management, the Columbia Valley is able to have leading harvests of juice grapes and to create quality wines that otherwise benefit from natural conditions of the region (physiography and climate). In this paper we explore the environmental issues of maintaining vineyards in arid climates such as central Washington. We ask:

(1) How should concepts of sustainability consider environmental stress? For example, which would be less sustainable: excessive environmental stress in grapes, and thus decreased harvests, or the alleviation of that stress with irrigation?
(2) When is environmental stress beneficial? When is it not sustainable?

Our vineyard research has focused on a condition in juice grapes known as blackleaf; a detrimental response to environmental conditions that exceed a threshold for acceptable stress. Using the two French land-related terms 'appellation' and 'terroir', we discuss the implications of such stress to agricultural sustainability; the fit of Concord grapes to the Columbia Valley appellation and terroir.

Geography of Washington Agriculture

The state of Washington, USA, is characterised by enormous physiographic and ecological diversity. The Cascade Mountains divide the state into two major climatic regions: the wet, forested west side and the sunny, arid east side. Along the eastern rain shadow, pine forests drop into the basalt rock canyons of the Columbia River basin, with desert sagebrush valleys covered by gravely or sandy soils. Rainfall is less than 25 cm along the Columbia and Yakima River valleys east of the Cascades, compared with over

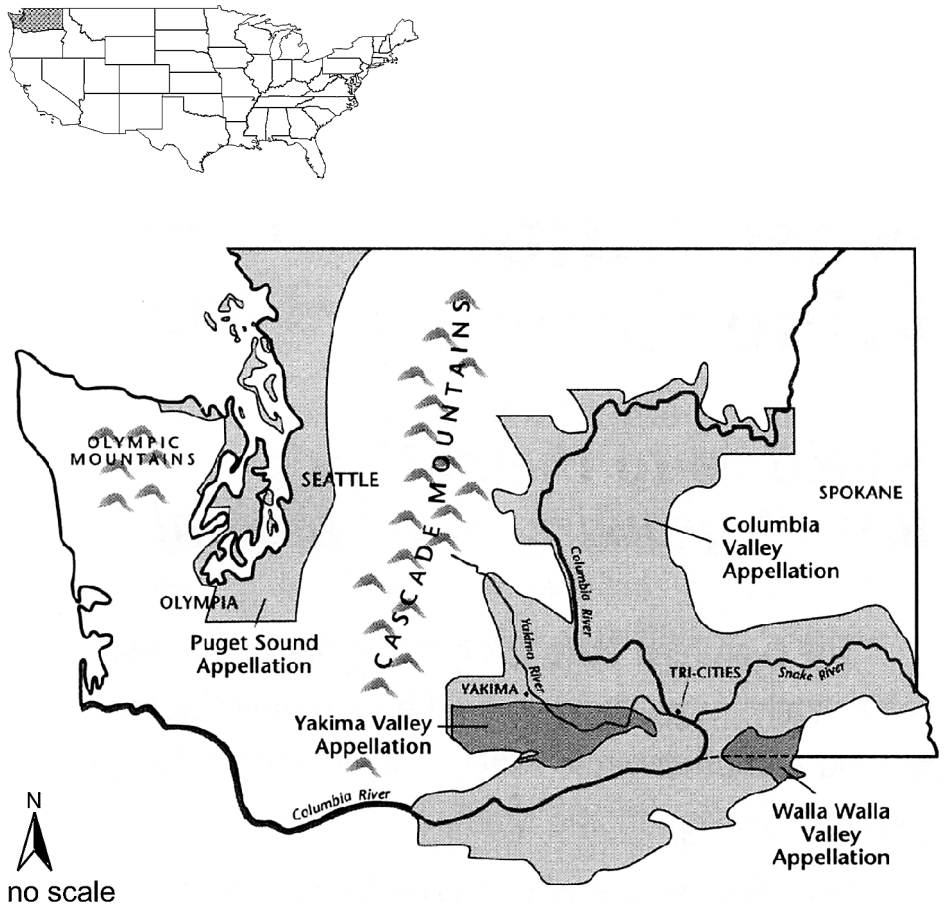

Figure 1 American Viticultural Areas (AVAs, similar to appellations in France) of Washington, USA. There are four AVAs in Washington: Columbia Valley in the central part of the state, Puget Sound to the west, Walla Walla in the southeast corner, and Yakima Valley in south central Washington. *Source:* Washington Wine Commission brochure (1997)

250 cm in the nearby mountain and coastal regions to the west (Ahmedullah & Watson, 1985). Not surprisingly, the agriculture, and especially the horticulture, of the state are equally diverse, from cranberries grown in coastal wetland environments, to a variety of crops grown under irrigation in the more arid regions. Although Washington is most noted for its apples and other tree fruits, it also leads the nation in the production of Concord, a variety of juice (or table) grapes, and is second only to California in the production of wine grapes (National Agricultural Statistics Service, 2001).

Appellation and Terroir of the Columbia Valley

Grapes are grown in geographic areas known as appellations, the 'identifying name of a defined wine area' (Wilson, 1998: 57). There are four appellations in Washington, which are called American Viticultural Areas (AVAs) and are regulated by the Bureau of Alcohol, Tobacco, and Firearms (Figure 1). Although there are vineyards on the west side of the Cascade Range in the Puget Sound appellation, most grape production is found in the Columbia Valley, Walla Walla Valley and Yakima Valley appellations in the arid regions of the state, under irrigation.

The word 'terroir', for which the French claim there is no complete English translation, is used to describe the combination of physical factors: the vine, subsoil, siting, drainage, and microclimate, along with the intangible spirit and history of the place that produce certain qualities in grapes, and thus in wine (Johnson & Robinson, 2001; Wilson, 1998). Terroir is a holistic concept that can be contrasted to the more systematic and scientifically based approaches to identifying those physical factors in North America (Haynes, 2000; Meinert & Busacca, 2000).

In a series on geology and wine for *Geoscience Canada*, Meinert and Busacca describe the physiographic characteristics of Southeast Washington:

> *Terroir* of the Walla Walla Valley *appellation* of Washington State is influenced by (1) the rain shadow effect and volcanic tephra of the Cascade Mountain Range, (2) soils derived from Quaternary glacial sediments and wind-blown loess overlying Miocene basalt, and (3) a warm, dry climate with abundant sunshine and cool nights due to high latitude (45°–48°N) and elevation. (Meinert & Busacca, 2000: 149)

Although they describe the Walla Walla Valley appellation specifically, very similar conditions exist throughout the Columbia Basin. A series of geologic events first reported by Bretz (1923, 1925) that have collectively become known as the Great Missoula Flood have had a profound influence on the terroir of the grape-growing regions of the Columbia Basin. As the floodwaters were constricted at Wallula Gap 100,000 to 10,000 years ago, the water backed up into tributaries of the Columbia River, perhaps upstream as far as the present day Hells Canyon Dam on the Snake River in Idaho (O'Connor & Baker, 1992). These floodwaters left slackwater deposits, locally called *Touchet beds* (Carson *et al*., 1978), which are relatively fine-grained and well-drained formations. Many of the vineyards in the Columbia Basin are located on productive loess soils overlaying these well-drained Touchet beds.

History of Washington vineyards

Vineyards have been a significant component of the agricultural landscape of Washington since the earliest settlements. The first known planting of grape vines was at Fort Vancouver, near the Pacific coast, in 1824 (Irvine & Clore, 1997). The first vineyard was planted with seeds brought from England, but the variety is not known. Juice grapes (*Vitis labrusca* L.), as well as wine grapes (*Vitis vinifera* L.), were grown in the southeastern part of the state at Walla Walla by 1836. By the late 19th century grapes were cultivated throughout most of the arid regions of eastern and central Washington, with Concords first grown in the arid regions of Washington in 1904 (Irvine & Clore, 1997).

As has been the case with nearly all other horticultural crops grown in Central Washington, water provided by irrigation projects fueled the rapid increase in land used for the production of grapes. By the end of the 19th century several small privately financed irrigation projects provided water to be used for the irrigation of grapes and other crops near Yakima (Irvine & Clore, 1997). Companies such as the Northern Pacific Railroad initiated larger-scale irrigation projects. These projects led to the creation of extensive plantations of Concord and other grapes, and the establishment of large commercial fruit processing plants throughout eastern and central Washington. Towards the middle of the 20th century, large federally sponsored irrigation projects, such as the construction of the Grand Coulee Dam, further enhanced agricultural production in the Columbia Valley (Washington State Office of Archaeology and Historic Preservation, 1989). Plantings of wine and juice grapes increased steadily throughout the last half of the 20th century to a total of about 16,000 ha, and in 2000, Washington State led the nation in the production of Concord juice grapes, accounting for nearly 41% of the national total (National Agricultural Statistics Service, 2001).

Stress and grape quality

Irrigation provides not only water to vineyards, but also a means for growers to manipulate stress, both by watering and withholding water. The concept of agricultural sustainability implies 'the better use of nature's goods and services, and of people's knowledge, technologies, and collective capacities' (Pretty *et al*., 2003: 1). A tangent of this concept suggests that stress to the given system is minimal so that the practice may persist indefinitely. Interestingly, in the case of grape production, some level of physiological stress is desirable. Gladstones reports that 'fruitfulness and grape quality have in the past largely depended on the combination of low vine vigor and summer trimming' (Gladstones, 1992: 46) and Peynaud notes:

> Somewhat paradoxically, quality wine areas are not necessarily those most favorable to the growth and production of the vine. The quality regions are rather marginal areas more subject to irregular annual climates and equally sensitive to microclimates. (Peynaud, 1984: 81)

The production of high quality grapes then, is a compromise between providing an environment that supports the growth of the vine while maintaining the level of stress necessary to produce

high quality fruit. In some cases, however, the stress becomes more acute.

The case of blackleaf

Grapevine blackleaf is a disorder that occurs in vineyards throughout the world, though much more predominantly in juice grapes than in wine grapes and more frequently in arid landscapes like those of Central Washington than in many others (Smithyman, 1999). Blackleaf symptoms occur on the upper sun-exposed leaves of the vine as a purplish to blackish discoloration on the leaf surface. With continued exposure the leaf darkens and dries, and eventually, the entire vine may become defoliated. When a large percentage of vines within a vineyard are defoliated, the grape yield also declines (Smithyman, 1999).

Traditionally, blackleaf in grape was thought to be associated with low potassium concentrations (Clore & Woodbridge, 1963; Shaulis, 1954). However, more recent research shows that blackleaf is not linked directly with potassium nutrition, but rather with a combination of high light, ultraviolet-B irradiation, and water deficit stress, which collectively induce blackleaf symptoms (Smithyman, 1999). Still, it is not clear why greenness declines more in some parts of a vineyard than others; why there is spatial variability in the sensitivity to light and heat stress. Further research on the physiological triggers is needed.

For three years (1996–1999), colleagues at Washington State University monitored the environmental stress of blackleaf in Washington vineyards. We looked for spatial pattern and variability in the disorder. Our work used vine-level digital image capture to measure seasonal declines in greenness as an indication of blackleaf spread, and to look for spatial patterns of blackleaf development within vineyards (Silbernagel & Lang, 2002). Concurrently, physiologists tested for triggers and experimented with management adaptations to decrease the sun and water stress (Lang *et al*., 1998).

Together we were able to characterise the spatial variability and seasonal trends of *greenness*, the reciprocal of blackleaf, and blackleaf development during subsequent seasons in Concord vineyards of the Yakima Valley. The results suggest that early season spatial pattern might be an indicator of where greenness is (or is not) developing. Patches with delayed greenness may represent areas of greater environmental stress that *exceed* an acceptable threshold for recovery. Recognition of early season stress could allow growers to apply adaptive management, such as shade structures, anti-transpirants, or most likely, modified irrigation to alleviate the effects. Success with Concord grapes in Eastern Washington depends on the extent to which growers can detect early season stress, when changes in vineyard management can alleviate water or light extremes, and whether they are willing to accept the environmental (and financial) costs for mid-season vineyard management Alternatively, lack of attention to spatially specific early season clues might lead growers to overwater or overmanage throughout the season.

Implications and Discussion

In France each appellation has its own terroir that a vigneron (French grape grower) should not attempt to change. Kramer (1989) explains that vignerons feel each terroir should be allowed to be itself and produce the wine for which nature endowed it. 'The land itself chooses the crop that suits it best' (Johnson, 1997 and supported by the author's personal communication with growers in the Loire Valley of France). But in the US, changing land use practices and modern technology have made possible geographic shifts in the cultivation or production of grape products that had been historically associated with particular regions and landscapes (Barham, 2003). While juice grapes are grown plentifully in the Columbia Valley, are these cultivation practices sustainable in this environment, in the long term? Are they sustainable if the costs of managing stress are considered?

First, in a traditional sense, terroir applies only to wine grapes, as a concept that evolved over a very long period of time. Some places where grapes are grown in France have been cultivated in vines for over a thousand years, which suggests a different landscape context than the 50–60 years that Concords have been extensively planted, or the 20–30 years that wine grapes have been extensively grown in Washington. Second, and perhaps more importantly, in France it is illegal to irrigate wine grapes that are grown in controlled appellations, so the concept of terroir takes on a much more complete meaning with regards to the inherent nature of a site for

growing grapes (Barham, 2003; Wilson, 2001). There are cultural inputs that could be called resource demands, but they are mostly in the form of fertilisers and the labour needed for certain cultural practices and are much less intense, at least from the point of view of sustainable energy and water.

Do the irrigated vineyards of Washington and California apply the concept of terroir too loosely as Wilson (2001) suggests? In the context of that described above, the traditional definition of terroir establishes a threshold that would, at least in part, be driven by the amount of rainfall needed to grow grapes. This touches on the fundamental issue associated with sustainability: the assumptions that are made about what is acceptable in terms of inputs to the system. In a strict interpretation of ecological principles, sustainability, or terroir, where human needs or passions for wine were not considered, then clearly the growing of grapes, either Concord or wine would not be appropriate in the Columbia Valley. However, sustainability is not only an ecological concept, but one that must be applied within the context of human values; what some refer to as a socioeconomic construct. As Pretty *et al*. state (2003: 1):

> . . . real progress can only come from a synthesis of the best knowledge and practices of the past, eliminating whatever causes damage to environments and human health, with the best of knowledge and technology available to us today.

Very high quality grapes, both Concord and wine, can be grown in the Columbia Valley because *most* of the natural conditions are ideal, and it is (generally) socially acceptable to supply the water (and the energy that implies) to make it possible. Even economically one could argue that this agricultural practice is sustainable. If the conditions of the Columbia Valley (the terroir) were such that only average to low quality jug wines could be produced, it is unlikely that the Washington wine industry could compete with California economically, and it would be far less robust than it currently is. Similarly, Washington would not continue to be the top state in Concord grape production if it could not produce nice yields of plump juicy grapes.

So how shall the international agricultural community consider environmental stress and adaptive management regarding sustainability? In this illustration, which would we consider less sustainable: the spread of blackleaf across a vineyard that causes a decline in yield and regional income, or site-specific management inputs to alleviate blackleaf symptoms and maintain a viable harvest?

We have used the case of *sunburn on the vineyard*, couched in the idea of *terroir*, to illustrate some issues yet to be resolved around the topic of agricultural sustainability. There are clearly environmental costs associated with the production of grapes in the Columbia Valley. But there are also environmental costs associated with the shipping of grapes or wine from France or New York State to Seattle, Washington. What is certain is that the production of grapes, and the creation of wines in the Columbia Valley supports the local economy, utilises natural conditions, and contributes to a regional agricultural identity, some of the requirements that Hawken (1993) identifies as needed for sustainable business. And Pretty *et al.* argue (2003: 1) 'It is possible, though not necessarily easy, to have diversity in both human and natural systems without giving up economic efficiency'. It seems that those conducting agricultural sustainability assessments need common, objective means to account for environmental and economic inputs, and the meaning of such practices to regional identity and long-term sustainability issues. In other cases, holistic concepts of sustainability, like 'terroir', will provide the best context for assessment.

Acknowledgements

The authors thank Drs Suzanne Lang, Robert Wample, and Russell Smithyman for their efforts in physiological studies of blackleaf in Concord grape vineyards of Washington. Spatial studies of blackleaf, conducted with Dr Suzanne Lang, were funded in part by grants from the Northwest Small Fruit Research Council and the Washington State Grape Commission. We also appreciate the advice and early reviews provided by Dr John Fellman, Dr Matthew Carroll and Dr Matthias Bürgi as well as revisions suggested by two anonymous reviewers.

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