Variety Trials

Evaluation of Winegrapes in British Columbia: New Cultivars and Selections from Germany and Hungary

Andrew G. Reynolds¹,
Margaret Cliff¹,
Douglas A. Wardle², and
Marjorie King²

ADDITIONAL INDEX WORDS. *Vitis*, breeding, clone

SUMMARY. Eighty-five cultivars, selections and clones of winegrapes (*Vitis*) from European breeding and selection programs were evaluated between 1993–95 in a randomized complete-block experiment. These included selections from Alzey, Freiburg, Geilweilerhof, Geisenheim, Weinsberg, and Würzburg (Germany); Hungary; and the former USSR. Vines were grown under an organic management regime that included sodium silicate

sprays for powdery mildew (*Uncinula necator*) control and oil + detergent for insect control but with little to no nitrogen or other nutritional inputs. The Weinsberg cultivars Heroldrebe and Helfensteiner showed promise viticulturally and sensorially as alternatives to 'Pinot noir'. Cultivars from Geisenheim ('Gm 7117-10' and 'Gm 7117-26') and Würzburg ('Cantaro' and 'Fontanara') appeared promising as 'Riesling' alternatives; many displayed similar sensory characteristics to 'Riesling', along with reasonable viticultural performance. Cultivars selected at Alzey ('Faberrebe'), Freiburg ('Nobling'), and Weinsberg ('Holder') displayed sensory characteristics superior to the standard cultivar Müller-Thurgau, with very intense muscat, pear, fig, and spicy aromas and flavors. Several muscat-flavored Hungarian white wine cultivars appeared to be superior viticulturally and sensorially to the standard 'Csabagyongye'; these included 'Kozma Palne Muscotaly', 'Zefir', and 'Zengo'. Miscellaneous red wine cultivars that showed promise included Geilweilerhof cultivar Regent, and Hungarian selections Kozma 55 and Kozma 525. Vine yields decreased substantially in the 3-year evaluation period, primarily due to lack of nitrogen. Many of these cultivars appeared to be highly adaptable to viticultural regions where cold winters and low heat units during fruit maturation presently restrict cultivar choices.

Numerous grape breeding programs exist throughout the world with objectives of introducing wine grape cultivars with improved adaptabilities to climatic adversities and pests. Many of the programs in Europe have focused on interspecific crosses involving *Vitis vinifera* that combine high wine quality

with resistance to diseases. Two well-known interspecific cultivars from the breeding program at Geilweilerhof, Germany, include 'Castor' and 'Pollux' [(‘Oberlin 595’)F₁ x ‘Foster’s White Seedling’; Alleweldt, 1980]. Many intraspecific *V. vinifera* winegrape cultivars and selections have also been bred to add to the cultivar diversity within various winegrowing regions of the world. Examples of these include 'Ehrenfelser' ('Riesling' x 'Sylvaner', 1929) from the breeding program in Geisenheim, Germany, and 'Scheurebe' ('Riesling' x 'Sylvaner', 1911) from the breeding station at Alzey, Germany (Becker 1984). As an adjunct to these programs, ongoing clonal selection programs for *V. vinifera* winegrapes focus upon cultivar improvement through selection of superior clones. 'Riesling', 'Chardonnay', and 'Pinot noir' are three cultivars from which several unique clones have been selected and named (Becker, 1984; Bernard and Leguay, 1984; Boidron, 1995).

As new vineyard regions are being established throughout North America, grapegrowers are increasingly demanding more choices in planting material. Frequently, expanding viticultural regions, such as the midwestern United States and northern Virginia (Wolf and Miller, 2001; Wolf and Warren, 2000), have adverse climatic conditions, primarily fluctuating winter temperatures, that prevent success of traditional *V. vinifera* winegrape cultivars. In the coastal regions of the Pacific Northwest, lack of heat units during fruit maturation is usually the mitigating factor. Little or no information is available from these regions documenting the performance of recently introduced European varieties, selections, and clones in specific regions of North America. Three notable exceptions are the clonal trials on 'Pinot noir' in Oregon (Price and Watson, 1995; Price et al., 1988; Watson et al., 1988) and New York (Pool et al., 1995), and those in California on numerous cultivars including 'Cabernet Sauvignon', 'Chardonnay', 'Merlot', and 'Zinfandel' (Bettiga, 1995; Wolpert, 1995).

Hundreds of interspecific hybrids, intraspecific *V. vinifera* cultivars, and clones of *V. vinifera* winegrapes have been bred or selected throughout Europe. Many of these have been selected for specific environmental conditions

Agriculture and Agri-Food Canada, Summerland, B.C. V0H 1Z0.

Acknowledgments: *Field and Lab*: Rochelle Eisen, field/lab technician; Martin Drew, assistant. *Winemaking*: Doug Wardle, technical assistant; Deepank Utkhede, summer student. *Tasting*: Mike Bouthillier, Margaret Cliff, Tony Cottrell, Pascal Delaquis, Marj King, Benoit Girard, Hilary Graham, Linda Herbert, Andy Reynolds, Laszlo Veto, Doug Wardle, Jim Wild.

^{1,2}Research scientist and technician, respectively. Present address of senior author: Cool Climate Oenology & Viticulture Institute, Brock University, St. Catharines, ON L2S 3A1, Canada.

and have had no evaluation under North American conditions. At the same time, many viticultural regions outside the traditional wine producing areas have become established throughout the United States and Canada, and these industries have created a demand for new varieties that are adaptable to the unique climatic conditions present in these regions. The objective of this study was to evaluate a large collection of winegrape cultivars and selections (both interspecific and intraspecific *V. vinifera*) in terms of field performance, fruit composition, and wine sensory attributes. Relative performances of 'Chardonnay' and 'Pinot noir' clones are described in a related publication (Reynolds, 1996a). Moreover, because a growing organic movement has been evident in British Columbia since the late 1980s, this trial was also regarded as an opportunity to gain some experience with organic viticulture across a wide range of cultivars. The latter approach was made possible and is considered justified because no downy mildew (*Plasmopara viticola*), black rot (*Guignardia bidwellii*), phomopsis leaf blight (*Phomopsis viticola*), or eutypa dieback (*Eutypa lata*) occur in the region.

Materials and methods

ENVIRONMENTAL CONDITIONS. Cultivars were evaluated at the Pacific Agri-Food Research Centre, Summerland, B.C., Canada. The site was situated in the Okanagan Valley, which is considered an arid continental climate. Elevation was 454 m (1488 ft) above sea level and latitude was 49°34'N. Mean annual precipitation for the test period was 287.8 mm (11.33 inches), of which 165.6 mm (6.52 inches) fell during the April to October growing season. Mean temperature of the warmest month (July) was 20.8 °C (69.44 °F); mean minimum winter temperature was -6.4 °C (20.48 °F); absolute minimum winter temperature was -15.7 °C (3.74 °F). Growing degree days (GDD; 10 °C base) were 1142.9 (2089.2 GDD using a 50 °F base) (Drought and Stretch, 1996).

EXPERIMENTAL DESIGN AND PLANT MATERIAL. All plant materials were obtained as rooted cuttings via the Centre for Plant Health, Saanichton, B.C. Incidence of phylloxera in the region is very low, and therefore own-rooted grapevines were not at risk of phylloxera injury. Soil type at the planting site was

Skaha gravelly sandy loam (Kelley and Spilsbury, 1949) with an organic matter content of 1.9% and a pH of 7.8 [British Columbia Ministry of Agriculture, Fisheries and Food (BCMAFF), 1992]. Vines were planted in May 1988 at 1.8 m × 2.7 m (6 ft × 9 ft; vine × row), trained to 0.6-m- (24 inches) high bilateral cordons, and pruned to enough two-node spurs to provide 15 shoots/m row (4.6 shoots/ft). Shoots were trained upwards in a vertical trellis and were trimmed at the tops around mid-July (berries < pea size). Vines were irrigated throughout the life of the planting by drippers spaced 1.0 m (40 inches) apart and delivering 4.5 L·h⁻¹ (1.19 gal/h). Irrigation began each season after the emergence of three to five leaves, and was operated until the last cultivars were harvested in late October. Water was applied for 2 h per day [14.4 L/vine (3.79 gal/vine) per day or 30,549 L·ha⁻¹ (3266 gal/acre) per day].

Pest control was done according to local recommendations (BCMAFF, 1996) from 1988–92 and organically thereafter. During 1993–95, powdery mildew was controlled by 1000 mg·L⁻¹ (ppm) sodium silicate applied five times between late May and early September. Research with potassium silicate, ongoing at the time of this trial, demonstrated its effectiveness as a grape powdery mildew prophylactic (Reynolds et al., 1996). Leafhoppers were controlled using two applications of 0.5% v/v (dormant oil) + (Tide) detergent (Proctor and Gamble, Toronto) during early summer. This was adapted from a combination of local practice within the organic community as well as encouraging results with plant-derived oils on grape powdery mildew and botrytis bunch rot control (Reynolds, 1996b). Thrips populations were suppressed by these measures, but not adequately. According to the Certified Organic Association of British Columbia (COABC) (2003), sodium silicate is an allowable product and dormant oil is a regulated item, but detergents are presently prohibited; use of Tide was therefore the only noncertified product used during the course of the trial. No nitrogen was applied during 1993–95 due to the nonavailability of sufficient quantities of any allowable certified organic source, such as: composted animal manures; green manures; miscellaneous composted organic materials; blood,

vegetable, or hoof and horn meals; fish meals and emulsions (COABC, 2003). Application of blood meal was attempted through the irrigation system, but this was unsuccessful (and hence abandoned) due to clogging of drippers.

Experimental design was a randomized complete block with 85 cultivars, selections and clones, four blocks, and three-vine treatment replicates. To facilitate data analysis, a series of sub-experiments were designated for the following groups of cultivars, selections, and/or clones, organized in terms of the country or experiment station of origin: 1) Alzey cultivars and selections; 2) Freiburg and Weinsberg cultivars and selections; 3) Geilweilerhof cultivars and selections; 4) Geisenheim cultivars and selections; 5) Würzburg cultivars and selections; 6) Hungarian muscat cultivars and selections; 7) Hungarian white wine cultivars and selections; 8) miscellaneous red wine varieties and selections. The complete list of cultivars, selections, and clones evaluated in this trial, along with their origins (Alleweldt and Dettweiler-Münch, 1992; Hillebrand et al., 1984), sorted according to the 1993 harvest dates, is found in Table 1. Performances of the 'Chardonnay' and 'Pinot noir' clones are described elsewhere (Reynolds, 1996a).

YIELD COMPONENTS. Harvest date was based on a 15-point scoresheet (Table 1) used to assess fruit maturity. Cultivars were sampled every 48 h and harvested once the fruit maturity index reached between 12 and 15. Yield per vine was recorded at harvest. A random 100-berry sample was taken from each treatment replicate to determine berry weight and chemical composition.

BERRY CHEMICAL COMPOSITION. Berry samples were juiced, and soluble solids concentration (SSC) and pH were measured thereon by a temperature-compensated Abbé refractometer (AO Scientific, Buffalo, N.Y.) and Fisher Accumet 825MP pH meter (Fisher Scientific, Vancouver, B.C.), respectively. Titratable acidity (TA) was measured with a Brinkmann automatic titrating ensemble (Metrohm, Herisau, Switzerland) and expressed as tartaric acid equivalents (Amerine and Ough, 1980).

WINEMAKING: MUST AND WIND COMPOSITION; SENSORY ANALYSIS. *Winemaking.* Based on preliminary data collected during a pilot project

Table 1. Harvest dates (listed sequentially for 1993) and origins for 79 winegrape cultivars evaluated at Summerland, B.C., in 1993–95.

Harvest date ^a	Cultivar or selection ^b	Origin: Parentage, origin, date of hybridization
6 Sept.	Csabagyongye Kozma Palne Muscotaly	Madeleine Angevine x Muscat Courtillier, Bekecsaba, Hungary, 1904 Italia x Irsai Oliver, Hungary
15 Sept.	Ortega Zefir	Muller-Thurgau x Siegerrebe, Wurzburg, 1948 Harslevelue x Leanyka, Badacsony, Hungary
22 Sept.	Blauer Frühburgunder Gf-111-28-51 Kozma CSFT 2423	Early-maturing Pinot noir clone Madeleine Angevine x Silvaner (Pannonia Kincse x Seyval blanc) x Kunbarat
24 Sept.	Huxelrebe Zengoe	Gutedelweiss x Muscat Courtillier, Alzey, 1927 Ezerjo x Bouvier, Badacsony, Hungary
27 Sept.	Juwel Gm 6497-4	Kerner x Silvaner, Weinsberg, 1951 No information available; Geisenheim selection
29 Sept.	Gloria Schonburger	Silvaner x Müller-Thurgau, Geilweilerhof Spatburgunder x (Chasselas rosa x Muscat Hamburg), Geisenheim, 1939
1 Oct.	Marechal Foch Gm 6427-5	101-14 (<i>V. riparia</i> x <i>V. rupestris</i>) x Goldriesling, Colmar Rötberger x Reichensteiner, Geisenheim
3 Oct.	Regner Agria	Luglienca bianca x Gamay noir, Alzey, 1929 (Teinturier x Kadarka) x (Medoc x Csabagyongye), Eger, Hungary
4 Oct.	Az-64-2-254 Bianca	No information available; Alzey selection Villard blanc x Bouvier, Eger, Hungary
8 Oct.	Nobling Phoenix Zalagyongye Michurinetz	Sylvaner x Gutedelweiss, Freiburg, 1939 Bacchus x Villard blanc, Geilweilerhof; registered 1992 Villard blanc x Csabagyongye, Eger, Hungary, 1957 <i>V. amurensis</i> x Getsch, Russia
13 Oct.	Okanagan Riesling Perle Ezerfurtue Kozma CSFT 195 Regent	<i>Vitis vinifera</i> x <i>V. labrusca</i> (?) Gewurztraminer x Müller-Thurgau, Alzey, 1927 Harslevelue x Piros Traminer Villard blanc x Csabagyongye, (Silvaner x Müller-Thurgau) x Chambourcin, Geilweilerhof; registered 1994
15 Oct.	Müller-Thurgau	Riesling x Silvaner
18 Oct.	Spätburgunder 52-86 Fr. Samtröt Pinot noir clone Q1342-01	Pinot noir clone, Freiburg Pinot Meunier clone, Schneider, Heilbronn Traditional <i>Vitis vinifera</i> ; French selection
22 Oct.	Merlot Zweigeltrebe Gm 6421-15 Gm 6423-3 Helfensteiner Heroldrebe Kozma CSVT 55 Kozma CSVT 525	Traditional <i>Vitis vinifera</i> Limberger x St. Laurent, Klosterneuberg, Austria Rötberger x Pinot noir, Geisenheim Rötberger x Heroldrebe, Geisenheim Portugieser x Limberger, Weinsberg, 1931 Frühburgunder x Trollinger, Weinsberg, 1929 Seibel 4986 x Csabagyongye No information available; Hungarian selection
24 Oct.	Weissburgunder cl. 5 Gm Castor Orion Pollux Silva Sirius NF-10-126 Ehrenfelser Gm 6414-11 Gm 6414-26 Gm 6414-36 Gm 643-20	<i>Vitis vinifera</i> ; clone selected at Geisenheim Oberlin 595 F ₂ x Foster's White Seedling, Geilweilerhof Optima x Villard blanc, Geilweilerhof (<i>V. riparia</i> x Gamay noir) F ₂ x Foster's White Seedling, Geilweilerhof; registered 1982 Bacchus x Villard blanc, Geilweilerhof Bacchus x Villard blanc, Geilweilerhof; registered 1984 Gf. 30N-5-82 x Noblessa, Geilweilerhof Riesling x Sylvaner, Geisenheim, 1929 Ehrenfelser x Reichensteiner, Geisenheim Ehrenfelser x Reichensteiner, Geisenheim Ehrenfelser x Reichensteiner, Geisenheim Riesling x Freiberg 148-39, Geisenheim

Table 1 continued on next page.

Table 1. Continued.

Harvest date ^z	Cultivar or selection ^y	Origin: Parentage, origin, date of hybridization
24 Oct. (continued)	Gm 6493-3	Saparavi Severnyi x Muscat Ottonel, Geisenheim
	Rieslaner cl. 3	Silvaner x Riesling, Wurzburg, 1921
	Rieslaner Q1335-01	Silvaner x Riesling, Wurzburg, 1921
	Goesseji Zamos	Eger 1 x Medoc noir, Hungary
	Karat	Steinschiller x Rulander, Hungary
	Kecskemet 13	Kadarka x Muscat Ottonel, Kecskemet, Hungary
	Kozma 194	Villard blanc x Csabagyongye, Kecskemet, Hungary
26 Oct.	Auxerrois	Traditional <i>Vitis vinifera</i>
	Riesling 21B	<i>Vitis vinifera</i> ; clone selected by H. Weis, Trier
	Riesling Ketter	<i>Vitis vinifera</i> ; clone selected by Ketter, Germany
	Faberrebe	Weissburgunder x Muller-Thurgau, Alzey, 1929
	Holder	Riesling x Rulander, Weinsberg, 1955
	Senator	Sylvaner clone, A. Lerch, Langenslonsheim, 1968
	Gm 6417-7	Ehrenfelser x 28-45 Ne, Geisenheim
	Gm 6423-12	Rötberger x Heroldrebe, Geisenheim
	Gm 646-2	No information available; Geisenheim selection
	Gm 6495-3	Saparavi Severniy x (Foster's White Seedling x Pracette), Geisenheim
	Gm 676-2	No information available; Geisenheim selection
	Gm 7116-26	Geisenheim 32358 x Ehrenfelser, Geisenheim
	Gm 7117-10	Geisenheim 31253 x Ehrenfelser, Geisenheim
	Gm 7117-13	Geisenheim 31253 x Ehrenfelser, Geisenheim
	Cantaro	Riesling x Sylvaner x (Müller-Thurgau), Würzburg, 1955
	Fontanara	Riesling x Sylvaner x (Müller-Thurgau), Würzburg, 1951
	Badacsony 10	Ezerjo x Bouvier, Badacsony, Hungary
	Eger 26	<i>Vitis vinifera</i> , Hungary
	Eger 30	<i>Vitis vinifera</i> , Hungary
	Suputinskyi Belyii	Itschimar x Dattier de St. Vallier, Russia

^zHarvest was based upon a 15-point subjective scale that encompassed color (0–2 points), ease of removal of berries from the pedicels (0–2 points), texture upon touch (0–1 point), texture upon initial bite (0–2 points), mechanical features of the pulp (0–2 points), aroma (0–2 points), flavor upon chewing (0–2 points), flavor release from the skin (0–1 point), and aftertaste (0–1 point).

^yAll vines were own-rooted.

in 1991 (BCMAFF 1992, 1993), 36 cultivars, selections and clones were chosen for winemaking in 1993. All fruit from each treatment replicate was retained from these cultivars at harvest in 1993 for winemaking. Cultivars not chosen for winemaking were those previously identified by members of the local industry as having undesirable sensory characteristics, or those not substantially different from cultivars already being grown (BCMAFF, 1992, 1993). Grapes were typically stored at 2 °C (35.6 °F) for 24 h, crushed in a Garolla crusher-destemmer, and the crushed grapes from each treatment replicate were collected in 20-L (5.3 gal) plastic pails. White wine grapes were pressed in a rack-and-cloth press 24 h after crushing, sulfited to 25 mg·L⁻¹ free sulfur dioxide (SO₂), settled at 2 °C for 24 h, and racked into 20-L glass carboys. Musts were inoculated with VL1 (*Saccharomyces cerevisiae*; Lallemant Corp., Montreal) yeast. Fermentations were carried out to dryness at 15 °C (59.0 °F). Fruit from each red wine grape treatment

replicate were crushed into individual 20-L fermenters, sulfited to 25 mg·L⁻¹ free SO₂, and separate primary fermentations were carried out using EC1118 yeast on each treatment replicate for 6 d at 30 °C (86.0 °F), after which the essentially dry wines were pressed. Caps were submerged two to three times daily by punching down. Fermentation was completed in glass carboys at 20 °C (68.0 °F). At the completion of fermentation, all wines were racked, sulfited to 50 mg·L⁻¹ SO₂, cold stabilized for 21 d at -2 °C (28.4 °F), and stored at 1 °C (33.8 °F) until bottling. Before bottling, fermentations from adjacent field blocks (blocks 1+2; blocks 3+4) were blended together in equal volumes to provide two composites for tasting. Wines were thereafter filtered through a 0.45-µm pad and a 0.22-µm cartridge prior to bottling.

Must and wine composition. A 250-mL (8.5 fl oz) must sample was collected from all white wine replicates immediately after pressing, and from all red wine replicates after crushing. Similarly, 250-mL samples were taken

from all wines prior to bottling; an additional set of samples was also taken from the red wines after pressing. Soluble solids concentration of the must, and TA and pH of the musts and wines were determined as previously described for the berry samples. Anthocyanins in the red wines were measured by the pH shift method (Amerine and Ough, 1980). Ethanol concentration in the wines was determined using a Hewlett-Packard 5700 gas chromatograph (Hewlett-Packard Canada, Mississauga, Ont.).

Sensory analysis. Sensory analyses were performed on the wines during Apr. to June 1997 after 36 months of bottle storage at 11 °C (51.8 °F) by a 12-member panel with prior wine evaluation experience and documented skills (based on 50% correct responses in triangle tests in several other related experiments). Aroma descriptors and retronasal aroma/tactile (flavor) descriptors were chosen by consensus following evaluation of numerous aroma and flavor samples (Table 2) and examples of wines produced from the

Table 2. Descriptors and standards used for sensory analysis of wines produced from German and Hungarian winegrape cultivars and selections at Summerland, B.C., in 1993.

Name of descriptor	Details of reference preparation
<i>Pinot noir alternatives^c</i>	
Cherry	1 mL each of natural cherry extract R-10242 ^y + imitation black cherry extract F-6534 ^y
Berry	1 mL each of these extracts ^y : imitation black raspberry F-3365, imitation strawberry F-5662, and natural + imitation raspberry R-895
Currant	250 mL syrup ^x
Plum/prune	350 mL 1981 experimental golden plum wine
Grassy/hay	300 mL 1993 experimental Semillon wine
Vegetal/bell pepper	1 mL vegetable extract 2M-44444 ^y
Black pepper/spicy	1 mL pepper extract 7407676 ^y
Licorice/anise	1 mL anise seed oil 1751 ^y
Caramel/candy	250 mL Andres medium dry Canadian sherry
<i>Riesling and alternatives; Müller-Thurgau and alternatives; Hungarian muscats^w</i>	
Floral	1 mL linalool
Lychee	100 mL canned lychee syrup
Citrus	0.25 mL each of lemon 531 ^y , orange 138216 ^x , grapefruit 138214 ^u , and lime 138212 ^u
Vegetal	0.25 g each of asparagus, celery, and cauliflower powders ^t
Peach/apricot	50 mL apricot syrup ^x
Cedar/pine	0.5 mL spruce beer 4691 ^y
Melon	Half of one honeydew melon, cubed, steeped for 20 min
Spicy	2 drops each of clove 1435 ^y , nutmeg 1427 ^y , spice blend TN-151-3 ^y , and cinnamon oils
<i>Miscellaneous reds^c</i>	
Berry	1 mL each of these extracts ^y : imitation black raspberry F-3365, imitation strawberry F-5662, and natural + imitation raspberry R-895
Currant	50 mL syrup ^x
Plum/prune	1 mL date type extract SPL 3333 ^y
Vegetal	250 mL 1993 experimental Semillon wine
Earthy	1 mL imitation mushroom extract F-6327 ^y

^aQuantities indicated were added to 1 L (33.8 fl oz) of experimental 1987 Gamay noir wine. 1.00 mL = 0.034 fl oz; 1.00 g = 0.035 oz.

^bGivaudin Ltd., Atlanta, Ga.

^cSummerland Sweets Ltd., Summerland, B.C.

^dQuantities indicated were added to 0.5 L (16.9 fl oz) neutral white wine.

^eQuest International Nederland BV, Naarden, The Netherlands.

^fAlex Fries, Inc., Cincinatti, Ohio.

^gFIS (Food Information Service), University of British Columbia, Vancouver, B.C.

^hQuantities indicated were added to 0.5 L of 1993 experimental Chancellor wine.

project. Descriptive analysis entailed 50-mL (1.7 fl oz) samples of each treatment presented randomly under white light in clear, tulip-shaped glasses. Panelists were initially requested to assess several aroma terms, after which the samples were removed, their numerical codes changed, and their order re-randomized for flavor assessment. The two tasting replicates were evaluated for each cultivar in separate sessions. A 100-mm- (3.9 inches) line scoresheet anchored at 0 (low) and extending to 100 (high) was used to quantify intensity of each aroma and flavor descriptor.

STATISTICAL ANALYSIS. All data were analyzed by cultivar within each group using SAS (SAS Institute, Cary, N.C.). The General Linear Models Procedure was utilized for analysis of variance with cultivar $\times$ block used as an error term. Sensory data were subjected to both analysis of variance and principal components analysis (PCA). PCA is a multivariate statistical technique that uses correlation coefficients to elucidate the nature of shared variability among several measured chemical and/or sensory variables (Noble, 1988). Intercorrelated variables, or factors, are then identified from the

data set. The group of factors that are responsible for the greatest degree of variability in the data set are referred to as principal component 1 (PC1). Most of the variability is usually explained in the first three PCs that are identified; the first two PCs are typically portrayed as a two-dimensional diagram with PC1 represented on the horizontal axis and PC2 on the vertical axis. Each sensory variable is depicted graphically as a vector (eigenvector) originating at the axis of PC1 and PC2; the length of each eigenvector is relative to the degree to which that variable contributes to the overall variability in the data set. Eigenvectors that are parallel to each other are considered highly correlated; those 180° from each other are inversely correlated. The position of each sample relative to the eigenvectors is reflective of their general sensory profile. The distance of each sample relative to the axis of PC1 and PC2 is proportional to the intensity of the sample. The SAS Means, Correlation, Factor Data, and Score Procedures were used for PCA.

Results and discussion

YIELD AND BERRY COMPOSITION. *Alzey cultivars.* Standard 'Müller-Thurgau' outyielded the four cultivars from the Alzey breeding program (Table 3). 'Huxelrebe' consistently had highest berry weight (Table 3). 'Faberrebe' had highest SSC and also highest TA in 1994–95 (Table 3). Soluble solids in both 'Faberrebe' and 'AZ 64-2-254' were above 26% SSC in 1994–95, but those of other cultivars were considerably lower, and each season most were within the 18% to 24% SSC range commonly considered desirable for winemaking (Table 3). TA values were also within the 5–10 g·L⁻¹ (5000–10,000 ppm) range considered desirable for winemaking (Table 3). No pattern was detected among the cultivars with respect to pH; all were within the 3.0 to 3.5 range considered desirable for winemaking (Table 3).

Freiburg and Weinsberg cultivars. Standard cultivar Müller-Thurgau tended to outyield the white wine cultivars from Freiburg and Weinsberg, with the exception of 'Juwel' (Table 3). 'Nobling' consistently had highest berry weights, while 'Holder' had lowest berry weights in 2 of 3 years (Table 3). 'Nobling' also had highest SSC in 2 of 3 years, and was the only white wine cultivar in this group that

**Table 3. Yield and berry composition of several winegrape cultivars and selections from European breeding programs, evaluated at Sum-
merland, B.C., in 1993–95. Cultivars in bold type within each table subsection are commercial standards.**

Origin and cultivar	Yield (t·ha ⁻¹) ^a			Berry wt (g) ^a			Soluble solids (%)			Titratable acidity (g·L ⁻¹) ^a			pH		
	1993	1994	1995	1993	1994	1995	1993	1994	1995	1993	1994	1995	1993	1994	1995
<i>White winegrape cultivars originating from Landessanstalt für Rebenzüchtung, Alzey, Germany (Rheinhesen)</i>															
Müller-Thurgau	17.2	10.2a	3.6a	1.34ab	1.10b	1.36b	17.8bc	21.9d	23.0e	7.3c	7.7b	5.4d	3.14b	3.16c	3.13e
Faberrebe	6.8	2.2c	1.6ab	1.23bc	0.88e	1.14c	22.8a	27.4a	26.5a	7.8bc	9.0a	7.9a	3.29a	3.01d	3.39b
Huxelrebe	2.0	6.9b	1.3ab	1.58a	1.70a	1.60a	17.0c	19.8c	24.8d	8.6b	7.6b	7.4b	3.15b	3.14c	3.31d
Regner	10.4	4.0c	1.7ab	0.94c	1.01c	1.11d	15.9c	23.0c	24.9c	8.4bc	7.3c	5.0e	3.13b	3.21b	3.40a
AZ 64-2-254	4.8	1.3c	0.92b	1.27ab	0.92d	0.92e	19.6b	26.3b	26.4b	9.9a	6.3d	7.0c	3.02c	3.24a	3.36c
Significance	NS	**	*	**	***	***	***	***	***	**	***	***	***	***	***
<i>Cultivars originating from Staatliches Weinbauinstitut, Freiburg (F) & Staatliche Lehr- und Versuchsanstalt, Weinsberg (W), Germany (Baden-Württemberg)</i>															
Müller-Thurgau	17.2a	10.2a	3.6ab	1.34bc	1.10c	1.36b	17.8c	21.9d	23.0d	7.3c	7.7c	5.4d	3.14b	3.16a	3.13c
Holder ^W	7.7ab	3.7b	2.3bc	1.06d	0.83d	1.11c	21.3ab	24.7b	24.1c	8.6b	9.1a	8.5c	3.18a	3.17a	3.25a
Juwel ^W	11.4ab	5.9ab	5.0a	1.36bc	1.19b	1.01d	19.4b	22.9c	24.8a	9.2a	8.2b	8.6b	2.88c	3.07c	3.13c
Nobling ^F	6.2b	4.0b	1.5c	1.63ab	1.37a	1.50a	22.7a	29.5a	24.4b	8.5b	7.1d	9.0a	3.14b	3.14b	3.21b
Significance (white grapes)	*	*	*	***	***	***	**	***	***	***	***	***	***	***	***
Spätburgunder															
52-86 Fr	10.6	4.1	6.1A	1.13B	0.84C	0.86C	20.0A	27.8A	25.8A	8.8A	7.2C	8.2B	3.15B	3.27A	3.19B
Helfensteiner ^W	13.7	6.2	2.7B	1.91A	1.91A	1.98A	19.0B	21.6C	21.7C	7.9A	7.9B	8.5A	3.09B	3.15C	3.11C
Heroldrebe ^W	12.7	6.4	3.3B	1.19B	1.13B	1.19B	18.7B	25.7B	24.8B	6.3B	8.1A	8.2B	3.25A	3.21B	3.24A
Significance (red grapes)	NS	NS	*	***	***	***	**	***	***	***	***	***	***	***	***
<i>Cultivars originating from Bundesforschungsanstalt für Rebenzüchtung Geilweilerhof, Siebeldingen, Germany (Rheinpfalz)</i>															
Riesling clone															
21B Weis	9.8b-e	2.8d	2.2bcd	1.14de	0.88i	0.95i	17.7f	21.9g	26.1c	10.5a	9.2bc	9.4a	3.01f	2.91i	3.15i
Müller-Thurgau	17.1ab	10.2bc	3.6bcd	1.34d	1.10g	1.36	17.8ef	26.5b	23.0i	7.3d	7.7e	5.4i	3.14e	3.16de	3.13j
Castor (B-7-2)	15.2abc	12.6b	5.9ab	1.79bc	1.73a	1.98a	20.6bcd	20.1i	24.9d	9.1b	10.0a	8.9b	3.26cd	3.13e	3.28e
Gloria	13.4bc	8.0c	5.1a-d	1.29d	1.24f	1.47d	18.4ef	23.2e	22.6j	6.6def	6.8f	6.9g	3.18de	3.18d	3.28e
Orion clone 6 (GA 58-30)	9.5b-e	4.4cd	3.3bcd	1.31d	1.12g	1.27f	21.0a-d	23.5d	26.6a	6.3ef	9.7b	7.6d	3.30bc	3.01h	3.27f
Phoenix (GA 49-22)	13.0bc	---	5.5abc	2.06a	---	1.81c	19.2cde	---	21.4k	5.9f	---	6.4h	3.32bc	---	3.18g
Pollux (B-6-18)	21.6a	17.6a	8.7a	1.74bc	1.68b	1.81c	19.5def	19.7j	23.5h	8.6c	8.9c	8.2c	3.31bc	3.19c	3.32c
Silva clone 5 (GA 54-14)	12.5bcd	5.9cd	3.6bcd	1.85b	1.58c	1.81c	21.6abc	22.3f	23.6g	6.9de	7.6e	7.4f	3.38b	3.25b	3.34b
Sirius (GA 51-27)	8.9b-e	3.7d	1.6cd	1.78bc	1.50e	1.83b	20.8bcd	23.7c	23.8f	7.2d	8.7d	8.2c	3.17de	3.04g	3.16h
Gf 111-28-51	4.1e	5.4cd	4.1bcd	1.57c	1.53d	1.24g	22.0a	20.4h	24.8e	3.8g	4.7h	3.1j	3.65a	3.41a	3.71a
NF 10-126	4.6de	5.3cd	1.1d	0.99e	0.96h	1.03h	21.6abc	27.1a	26.2b	6.5def	8.7d	7.5e	3.25cd	3.07f	3.31d
Significance	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***
<i>Cultivars originating from Institut für Rebenzüchtung, Geisenheim, Germany (Rheingau)</i>															
Riesling clone															
21B Weis	9.8c-f	2.8d-g	2.2cd	1.14efg	0.88i	0.95p	17.7gh	21.9q	26.1b	10.5b	9.2c	9.4c	3.01hij	2.91n	3.15j
Senator	1.0g	2.0fg	6.1a	1.14efg	1.23d	1.02o	29.4a	32.8a	23.2n	7.2ijk	4.2q	6.7n	3.61a	3.64a	3.45a
Gm 6414-11	12.4a-f	5.2a-f	1.3d	1.24def	0.83l	1.30g	18.9d-h	26.5h	23.8k	7.7hij	5.4p	6.9m	3.09ef	3.13e	3.33b
Gm 6414-26	5.9fg	2.3efg	2.8bcd	1.22d-g	0.83l	1.31f	20.4c-f	23.8l	24.3h	7.9hij	8.5g	7.4k	3.10e	3.14d	3.24d
Gm 6414-36	8.6def	4.0c-g	3.0a-d	1.32cde	0.83l	1.36c	21.0bcd	23.9k	24.5f	8.1f-i	8.8e	7.6j	3.10e	3.02i	3.18h
Gm 6417-7	13.9a-e	4.3b-g	1.6d	1.19d-g	0.91h	1.25i	18.1fgh	23.0n	23.3m	9.0c-f	7.9h	7.7i	3.07e-h	3.11f	3.24d
Gm 6423-12	14.1a-d	5.5a-f	3.2a-d	1.37cd	1.30b	1.32e	21.4bcd	30.2c	27.6a	9.6c	6.8m	7.9g	3.02g-j	2.95l	3.17i
Gm 6427-5	11.0a-f	7.9ab	3.7a-d	1.58ab	1.30b	1.52b	18.5e-h	22.5o	24.8e	9.0c-f	7.5i	7.8h	3.02g-j	3.08g	3.14k
Gm 643-20	17.0ab	5.6a-f	4.2a-d	1.14efg	1.03e	1.15l	17.5gh	21.8q	21.6q	6.7k	7.0l	7.7i	3.29b	3.24c	3.31c
Gm 646-2	16.4abc	5.1a-f	3.1a-d	1.08fg	0.92g	1.05n	20.9b-e	26.7g	25.4c	9.3cde	10.7b	7.9g	3.03f-j	2.94m	3.12l
Gm 6493-3	12.1a-f	2.3efg	5.7ab	1.24def	1.02f	1.24j	17.8gh	26.4i	21.9p	7.9hij	7.4j	8.1f	3.06e-i	2.97k	2.92p
Gm 6495-3	17.9a	8.2a	3.6a-d	1.74a	1.55a	1.63a	21.6bc	28.2d	22.8o	8.2fgh	8.6f	8.2e	3.21cd	3.04h	2.99n
Gm 6497-4	10.7b-f	6.3a-d	3.0a-d	1.32cde	1.27c	1.29h	20.9b-e	23.1m	24.2i	8.8c-g	7.1k	5.9o	3.08efg	3.31b	3.32b
Gm 676-2	14.9a-d	5.9a-e	2.1cd	1.17d-g	0.85j	1.18k	23.0b	27.7e	23.6l	9.4cd	6.6n	8.4d	3.11e	3.11f	3.21f
Gm 7116-26	12.8a-f	7.2abc	5.2abc	1.23d-g	0.82m	1.11m	21.6bc	26.3j	25.1d	8.3e-h	6.5o	7.5k	3.11e	3.00j	3.20g
Gm 7117-10	8.8def	6.5a-d	3.0a-d	1.26def	0.84k	1.33d	20.9b-e	27.3f	24.4g	10.9ab	10.9a	10.4a	2.99j	2.87o	3.26o
Gm 7117-13	5.9fg	1.1g	1.3d	1.21d-g	0.88i	1.18k	20.0c-g	30.5b	23.9j	11.7a	8.9d	9.7b	2.99j	3.14d	3.02m
Significance (white grapes)	***	***	**	***	***	***	***	***	***	***	***	***	***	***	***

Table 3 continued on next page.

Table 3. Continued.

Origin and cultivar	Yield (t·ha ⁻¹) ^z			Berry wt (g) ^z			Soluble solids (%)			Titratable acidity (g·L ⁻¹) ^z			pH		
	1993	1994	1995	1993	1994	1995	1993	1994	1995	1993	1994	1995	1993	1994	1995
Pinot noir															
Q1342-01	6.7B	6.3A	0.5C	1.09B	0.86C	1.04C	23.4A	27.0A	25.0B	7.5A	7.1A	6.6B	3.29A	3.25A	3.33B
Gm 6421-15	17.3A	5.8AB	1.6B	1.47A	1.24A	1.58A	18.1B	23.3C	25.6A	7.1AB	6.3B	7.6A	3.23B	3.19B	3.29C
Gm 6423-3	12.4AB	3.4B	2.9A	1.31AB	1.08B	1.40B	16.9C	25.7B	24.5C	6.4B	5.7C	6.6B	3.21B	3.25A	3.40A
Significance (red grapes)	*	***	***	***	***	***	**	***	***	***	***	***	***	***	***
<i>Cultivars originating from Bayerische Landesanstalt für Wein-, Obst- und Gartenbau, Würzburg-Weitzhoheim, Germany (Franken)</i>															
Riesling clone															
21B Weis	9.8	2.8b	2.2	1.14b	0.88c	0.95c	17.7c	21.9d	26.1c	10.5a	9.2a	9.4a	3.01e	2.91d	3.15d
Cantaro	8.3	3.1b	2.8	1.01b	0.93c	1.03c	24.0a	29.3a	25.9b	8.0c	7.5c	7.6b	3.22bc	3.06a	3.17d
Fontanara	9.8	3.4b	1.7	1.05b	1.08b	1.19b	20.4ab	27.6c	25.5d	7.9c	8.8b	6.0c	3.18cd	3.04b	3.31b
Ortega	7.8	8.9a	4.0	1.59a	1.41a	1.58a	21.6ab	19.5e	24.3d	9.6ab	7.3d	4.7d	3.24b	2.98c	3.32a
Perle	6.3	--- ^y	--- ^y	0.93b	---	---	18.1b	---	---	5.5d	---	---	3.49a	---	---
Rieslaner clone 3	9.3	4.3b	1.5	1.01b	0.84d	0.88d	21.1ab	29.0b	28.4a	10.4a	9.0a	9.9a	3.13d	3.06a	3.25c
Rieslaner															
Q1335-01	10.0	--- ^y	--- ^y	0.99b	---	---	20.3ab	---	---	9.3b	---	---	3.15cd	---	---
Significance	NS	***	NS	***	***	***	*	***	***	***	***	***	***	***	***
<i>Hungarian muscat-flavored winegrape cultivars</i>															
Csabagyongye	4.8c	--- ^y	--- ^y	1.48b	1.96b	---	18.9a	21.5d	---	7.2d	6.2e	---	3.29a	3.46a	---
Gocseji															
Zamatos	4.8c	7.5a	3.1	1.47b	1.22d	1.19c	21.1a	21.7c	24.4d	9.7b	9.7b	10.5a	3.10b	3.05d	3.16c
Kozma Palne															
Muscotaly	9.2ab	4.7b	--- ^y	2.11a	2.30a	1.81a	16.4b	17.3	27.6a	6.9d	6.6c	4.0d	3.26a	3.32b	3.69a
Zefir	8.1bc	4.8b	2.1	1.21c	1.04	1.04d	21.2a	23.3a	27.0b	8.5c	6.4d	4.8b	3.34a	3.20c	3.63b
Zengo	12.4a	7.6a	3.7	1.65b	1.73c	1.54b	19.1a	22.3b	26.7c	11.4a	11.4a	8.7c	2.93c	2.83e	3.09d
Significance	**	**	NS	***	***	***	**	***	***	***	***	***	***	***	***
<i>Hungarian white winegrape cultivars and selections</i>															
Bianca	11.1abc	5.8ab	6.0a	1.58b	1.43c	1.44c	23.3abc	30.0a	25.8d	9.5cd	6.9h	8.6d	3.29bc	3.34a	3.37b
Ezerfurtue	11.7ab	6.7ab	4.6ab	1.06ef	1.05g	1.15g	21.1b-c	24.5f	26.9c	6.7g	7.8f	6.4h	3.18cde	3.19b	3.35c
Karat	4.9bcd	3.4bc	2.4bc	1.20de	1.03h	1.18f	22.9a-d	24.0h	24.3h	8.3ef	8.3e	8.4e	3.16de	3.11f	3.21e
Zalagyongye	5.9bcd	3.4bc	2.1bc	1.59b	1.37d	1.36c	25.5a	23.6i	24.3g	6.9g	8.4d	6.8g	3.29bc	3.08g	3.05k
Badacsony 10	8.8a-d	3.4bc	2.4bc	1.33cd	1.08f	1.18f	22.6a-e	26.4c	29.7a	12.8a	12.9a	11.5a	3.00f	3.01i	3.17g
Eger 26	4.5cd	2.0c	1.5bc	1.87a	1.81a	1.65a	19.8e	25.5d	24.0i	9.6cd	7.6i	9.9b	3.17de	2.96j	3.09i
Eger 30	2.8d	3.7bc	1.11c	1.15de	0.91j	0.79i	24.9a	26.6b	28.0b	7.8efg	6.8g	6.4h	3.44a	3.07h	3.42a
Kecskemet 13	3.1d	2.0bc	1.8bc	1.51bc	1.35e	1.41d	20.2de	25.3e	21.6k	8.5de	6.1j	9.3c	3.16de	3.17c	3.16h
Kozma 195	13.7a	6.5ab	6.1a	1.69ab	1.60b	1.64b	20.8cde	24.0h	24.6f	8.6de	9.2b	7.4f	3.14de	3.15d	3.23d
Kozma 194	3.5d	4.2abc	1.9bc	0.91f	0.89k	0.66j	23.4abc	24.4g	23.9j	7.2fg	5.9k	6.2i	3.31b	3.14	3.06j
Kozma 2423	10.8abc	7.1a	3.2abc	1.20de	1.03h	1.06h	20.1de	21.2j	25.1	8.2ef	8.9c	5.8j	3.08def	3.07h	3.20f
Significance	***	**	***	***	***	***	***	***	***	***	***	***	***	***	***
<i>Red winegrape cultivars</i>															
Merlot	16.0a	5.0c	1.5b	1.21b	0.99f	0.98	19.9c	27.7a	25.0c	8.2c	6.9e	8.2e	3.15c	3.13d	3.16d
Agria	5.8d	2.7c	2.1b	1.15b	1.55b	0.96f	19.0c	24.0f	22.3g	6.2d	5.5f	5.5g	3.49a	3.58a	3.51a
Michurinetz	9.0bcd	10.9a	4.6a	0.91c	1.07e	1.01d	23.4b	22.3g	24.5d	11.9a	13.4a	10.8b	3.10c	2.95f	3.10e
Regent	7.8cd	6.2bc	1.2b	1.58a	1.68a	1.10c	22.8b	25.6d	22.4f	8.2c	7.4d	8.1f	3.29b	3.10e	3.22c
Zweigeltrebe	7.4cd	2.5c	1.9b	1.19b	1.20d	1.11b	19.2c	24.1e	24.1e	7.7d	7.5d	8.4d	3.15c	3.14c	3.06f
Kozma 55	16.3a	8.6ab	4.3a	1.05bc	0.91g	0.79g	22.4b	27.6b	25.2b	10.1b	8.8b	11.3a	3.17c	3.22b	3.10e
Kozma 525	13.9ab	5.8bc	1.5b	1.22b	1.34c	1.38a	20.4c	26.8c	26.7a	9.6b	7.8c	9.3c	3.11c	3.11e	3.23b
Significance	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***

^z1.0 t·ha⁻¹ = 0.446 ton/acre, 1.00 g = 0.035 oz, titratable acidity is expressed as tartaric acid in g·L⁻¹ (1.0 g·L⁻¹ = 1000 ppm).

^yYield not measurable due to vine injury suffered during the previous winter season.

NS, *, **, ***Nonsignificant or significant at $P \leq 0.05$, 0.01, and 0.001, respectively. Means followed by different letters are significant at $P \leq 0.05$, Duncan's multiple range test. Where both red and white winegrape cultivars appear within a table subsection, lowercase designations refer to white winegrapes, while uppercase designations refer to red winegrapes.

fell outside the desirable range; 'Müller-Thurgau' was lowest throughout the trial (Table 3). 'Müller-Thurgau' was additionally lowest in TA in all 3 seasons but all white wine cultivars had TA values within desirable parameters (Table 3). 'Juwel' had lowest pH in 1993–94, and was the only cultivar that fell outside of the desirable pH range for winemaking in 1993, suggesting that it may have been harvested somewhat prematurely (Table 3). The two red wine cultivars Heroldrebe and Helfensteiner did not differ in terms of yield from the standard 'Spätburgunder' clone 52-86 Fr. except in 1995, but 'Helfensteiner' produced substantially larger berries that approached 2 g in weight (Table 3). This high berry weight could potentially pose an issue for extraction during fermentation, since color, flavor compounds, and phenolics are dependent upon high skin : juice ratios associated with low berry weights. 'Heroldrebe' and 'Helfensteiner' were also lower in SSC than 'Spätburgunder'; 'Helfensteiner' tended towards highest TA and lowest pH in 2 of 3 years; however, both of the red wine cultivars had berry composition values within desirable parameters (Table 3).

Geilweilerhof cultivars. The interspecific hybrid 'Pollux' consistently outyielded standards 'Riesling' and 'Müller-Thurgau' (in 2 of 3 years) throughout the trial (Table 3). 'Castor' also produced high yields as well as highest berry weights in 2 of 3 seasons (Table 3). Selection 'NF 10-126' and 'Orion' produced berries with highest SSC, and these values were somewhat outside the range of desirability; 'Riesling' produced lowest SSC in 2 of 3 seasons (Table 3). Selection 'Gf 111-28-51' consistently produced berries with lowest TA [3.1–4.7 g·L⁻¹ (3100–4700 ppm)] and highest pH (3.41–3.71); these values were somewhat outside the range of commercial acceptability and suggest that this cultivar was not harvested early enough. Highest TA and lowest pH were consistently found in 'Riesling' and/or 'Müller-Thurgau' berries; these and the values measured on most of the other cultivars were within acceptable ranges for winemaking (Table 3).

Geisenheim cultivars. Most selections produced yields greater than or equal to the standard cultivar Riesling. Selections 'Gm 6495-3', 'Gm 643-20', and 'Gm 646-2' were notable in terms

of their overall productivity (Table 3), whereas 'Gm 7117-13' and 'Senator' tended to be lowest-yielding. 'Gm 6495-3' also produced the highest berry weight each season (Table 3). Most selections produced higher SSC than 'Riesling' each season; some such as 'Senator', 'Gm 7117-13', and 'Gm 6423-12' produced highest SSC, with concentrations exceeding 30% in 1994, suggesting that they may have been harvested too late (Table 3). Selections 'Gm 7117-10' and 'Gm 7117-13' produced berries with highest TA, with lowest values occurring each season in 'Senator' (Table 3). 'Gm 7117-10' also tended to have lowest pH values, with highest values (outside of desirable winemaking range) occurring consistently in 'Senator' (Table 3). Red wine selections Gm 6421-15 and 6423-3 produced yields greater than or equal to the 'Pinot noir' standard in 2 of 3 years (Table 3). Gm 6421-15 produced highest berry weights each season and 'Pinot noir' the lowest (Table 3). Soluble solids, TA, and pH values tended to be highest in the 'Pinot noir' berries and Gm 6423-3 had lowest values for SSC (2 of 3 years) and TA (Table 3).

Würzburg cultivars. The various cultivars from the Würzburg breeding program did not differ from 'Riesling' or from each other in terms of yield in 1993 or 1995, but 'Ortega' was highest-yielding in 1994 and had highest berry weights throughout (Table 3). 'Cantaro' berries had highest SSC in 2 of 3 years and the 1994–95 values were outside the normally acceptable range for white wines, while 'Ortega' had lowest SSC (Table 3). 'Rieslaner' had highest TA in all 3 years, and 'Ortega' had lowest in 2 of 3 seasons (Table 3). All TA values were within acceptable parameters. No consistent pH patterns were noted amongst the cultivars; most pH values were within acceptable parameters for winemaking.

Hungarian muscat-flavored white wine cultivars. Three of the muscat-flavored cultivars outyielded 'Csabagyongye' in 1993, and 'Zengo' was consistently the highest yielding throughout the 3 years (Table 3). Although 'Csabagyongye' has been grown commercially in BC for many years, severe winter injury in the 1993–94 winter prevented it from being used as a standard against which to compare the other cultivars in 1994–95. 'Kozma Palne Muscotaly' produced the larg-

est berries throughout the course of the trial, while 'Zefir' produced the smallest berries (Table 3). 'Zefir' also had highest SSC in 2 of 3 years and 'Kozma Palne Muscotaly' had lowest percent SSC in the same 2 seasons but this pattern was not apparent in 1995 (Table 3). Soluble solids were within acceptable ranges in 1993–94 for all cultivars, but somewhat high in 1995 (Table 3). 'Zengo' berries had highest TA in 2 of 3 seasons and the lowest pH throughout the trial; 1993–94 values were somewhat outside acceptable ranges for winemaking, suggesting premature harvest (Table 3). 'Csabagyongye', 'Kozma Palne Muscotaly', and 'Zefir' were usually those cultivars with lowest TA and highest pH; the values of the latter two cultivars were outside acceptable winemaking parameters in 1995 (Table 3).

Hungarian white wine cultivars.

Several cultivars and selections were relatively high-yielding, including 'Kozma 195', 'Kozma 2423', 'Bianca', and 'Ezerfurtue', and all outyielded 'Zalagyongye', which has been grown commercially in British Columbia for many years (Table 3). 'Eger 26' consistently produced highest berry weights, while smallest berries occurred in 'Kozma 194' (Table 3). There were no discernible patterns amongst the cultivars with respect to SSC; a few exceeded the upper limits of parameters usually considered acceptable for winemaking (Table 3). TA was consistently highest in 'Badacsony 10', while 'Eger 30' tended to have highest pH in 2 of 3 years (Table 3).

Miscellaneous red wine cultivars.

Vitis amurensis hybrid 'Michurinetz' and Hungarian selection 'Kozma 55' were consistently the highest yielding cultivars amongst this group, although they did not outyield the standard, 'Merlot', in 1993 (Table 3). The Hungarian cultivar Agria and Austrian cultivar Zweigeltrebe were lowest yielding in 2 of 3 seasons. The Geilweilerhof introduction 'Regent' produced largest berries in 2 of 3 seasons, while 'Michurinetz' (1993) and 'Kozma 55' (1994–95) were smallest (Table 3). No discernible and consistent pattern was apparent amongst this group of cultivars in terms of SSC, although 'Agria' and 'Michurinetz' tended to be lowest throughout the trial; a few cultivars exceeded the upper limits of parameters usually considered acceptable for red winemaking in 1994–95

(Table 3). 'Agria' also produced berries with lowest TA and highest pH, while 'Michurinetz' was consistently high in TA and low in pH (Table 3). All cultivars except 'Michurinetz' consistently produced fruit with acceptable TA and pH values (Table 3).

MUST AND WINE COMPOSITION.

Alzey cultivars. 'Faberrebe' was the only Alzey cultivar chosen for winemaking. 'Faberrebe' had higher must SSC, TA, and pH than standard cultivar Müller-Thurgau, as well as higher wine pH and ethanol (Table 4).

Freiburg and Weinsberg cultivars. 'Holder', 'Juwel', and 'Nobling' were chosen for winemaking and were compared against standard 'Müller-Thurgau'. 'Holder' and 'Nobling' had highest must SSC and 'Müller-Thurgau' was lowest (Table 4). 'Müller-Thurgau' was additionally lowest in must and wine TA, while 'Juwel' had highest must and wine TA and lowest must and wine pH (Table 4). The two red wine cultivars, 'Heroldrebe' and 'Helfensteiner', did not differ from each other in terms of must SSC, ethanol, and wine pH, but were less than the standard 'Spätburgunder' clone 52-86 Fr. (Table 4). 'Helfensteiner' produced substantially higher must TA and wine TA and lower must pH than both 'Spätburgunder' and 'Heroldrebe' (Table 3). 'Heroldrebe' wines were most intensely colored based upon anthocyanin concentration; the range of anthocyanins increased from 38.2–84.0 mg·L⁻¹ at pressing (Table 4) to 91.9–151.9 mg·L⁻¹ at bottling (data not shown).

Geisenheim cultivars. Preliminary data (BCMAFF, 1992, 1993) suggested that most of the Geisenheim selections in the trial were not appreciably different from the standard cultivar Riesling, or had no unique sensory attributes; thus, only four selections ('Gm 6497-4', 'Gm 676-2', 'Gm 7116-26', and 'Gm 7117-10') were retained for winemaking. All selections produced musts greater in SSC than the standard cultivar Riesling, and three of the four had higher ethanol concentration as well (Table 4). Selections 'Gm 6497-4', 'Gm 646-2', and 'Gm 7116-26' had lower must and wine TA and higher must and wine pH than 'Riesling' (Table 4). The red wine selections 'Gm 6421-15' and 'Gm 6423-3' produced neutral red wines that were no better than 'Pinot noir' standard in preliminary trials (BCMAFF, 1992,

1993); therefore, no red wines were made from any Geisenheim selections in this trial.

Würzburg cultivars. Except for the early-maturing 'Perle', the various cultivars from the Würzburg breeding program produced musts with higher SSC than the 'Riesling' standard (Table 4). 'Cantaro' berries had highest must percent SSC and highest corresponding ethanol in the wine (Table 4). 'Rieslaner' had highest must and wine TA, and lowest must and wine pH, while 'Perle' had lowest must SSC and ethanol, lowest must and wine TA, and highest must and wine pH (Table 4).

Hungarian muscat-flavored white wine cultivars. Four of the five muscat-flavored cultivars, including standard 'Csabagyongye', were retained for winemaking in 1993. 'Goejseji Zamatos' did not produce sufficient fruit for replicate fermentations. All cultivars had higher must SSC than 'Csabagyongye', but only 'Zefir' had higher corresponding ethanol (Table 4). 'Zengo' was highest in must and wine TA and lowest in must and wine pH (Table 4). 'Zefir' had lowest wine TA and highest must and wine pH; 'Kozma Palne Muscotaly' and 'Csabagyongye' had lowest must TA (Table 4).

Hungarian white wine cultivars. Amongst the many cultivars and selections that were tested, few demonstrated any unique sensory attributes in preliminary trials (BCMAFF, 1992, 1993). Hence, only 'Bianca' and 'Badacsony 10' were retained for winemaking in this trial. The two cultivars did not differ from each other in terms of must SSC and corresponding ethanol, but 'Badacsony 10' had higher must and wine TA, and lower must and wine pH (Table 4).

Miscellaneous red wine cultivars. All cultivars were equal to or greater than the standard 'Merlot' in must SSC and, 'Michurinetz' excepted, in ethanol (Table 4). 'Michurinetz' was highest amongst this group of cultivars in terms of must SSC, ethanol, and must and wine TA (Table 4). 'Regent' produced musts and wines with lowest TA and highest pH (Table 4). Both 'Michurinetz' and 'Regent' produced most intensely colored wines; all anthocyanin concentrations in the wines at pressing were higher than 'Merlot' (Table 4). Low ethanol values may have been due to formation of acetic acid

or ethyl acetate during the latter stages of primary fermentation, although no volatile acidity was noted by the sensory panel.

SENSORY ANALYSIS. 'Riesling' alternatives. All the Geisenheim and Würzburg cultivars and selections were tasted as a group to assess their potential as 'Riesling' alternatives. Several of these cultivars were greater than or equal to 'Riesling' in terms of desirable floral, spicy, and citrus aromas (Fig. 1). 'Fontanara' was noteworthy as a cultivar with intense floral and spicy aromas and low intensity of earthy, diesel, and vegetal aromas (Fig. 1). 'Gm 676-2' was distinctive because it had a high hybrid-like nose reminiscent of cooked strawberries. Several cultivars ('Cantaro', 'Rieslaner', 'Gm 676-2', 'Gm 7116-26', and 'Gm 7177-10') were also identified as having intense earthy aromas. The diesel (or "petrol") character often associated with aged 'Riesling' was very prominent in 'Gm 7117-10' (Fig. 1). 'Riesling' was highest in citrus flavor, but the majority of the other cultivars surpassed or equaled 'Riesling' in terms of floral, spicy, peach, and apple flavors (Fig. 2). Four cultivars ('Cantaro', 'Fontanara', 'Gm 676-2', and 'Gm 7116-26' displayed an undesirable "hybrid" note in their retronasal aromas. The diesel characteristic was noticeable in all wines and was particularly prominent in 'Fontanara', 'Gm 7117-10', 'Gm 676-2', and 'Gm 7116-26' (Fig. 2).

PCA showed that spicy, peach, floral, and hybrid aromas and flavors were aligned along PC1 and correlated with each other (Fig. 3). Citrus and apple aroma and flavors, acidity, and tannin were aligned in the opposite direction along PC1, indicating that these attributes were inversely correlated with the aforementioned sensory descriptors. Earthy, diesel, and vegetal aromas and flavors were aligned along PC2 and were therefore unrelated to the other sensory attributes. The two 'Riesling' samples as well as 'Rieslaner' and 'Gm 6497-4' were characterized by citrus, apple, acidity, and tannin (Fig. 3). 'Cantaro', 'Fontanara', 'Gm 676-2', and 'Gm 7116-26' were best characterized by floral, spicy, peach, and hybrid attributes, while 'Gm 7117-10' was described best by vegetal, earthy, and diesel descriptors (Fig. 3).

Müller-Thurgau and alternatives. White wine cultivars from the Weinsberg and Freiburg breeding pro-

Table 4. Must and wine composition of several winegrape cultivars and selections from European breeding programs, evaluated at Summerland, B.C., in 1993. Cultivars in bold type within each table subsection are commercial standards.

Origin and cultivar	Must composition			Wine composition			Total anthocyanins after press [mg·L ⁻¹ (ppm)]
	Soluble solids (%)	Titrateable acidity (g·L ⁻¹) ^z	pH	Ethanol (%)	Titrateable acidity (g·L ⁻¹) ^z	pH	
<i>White winegrape cultivars originating from Landessanstalt für Rebenzüchtung, Alzey, Germany (Rheinessen)</i>							
Müller-Thurgau	17.8	6.2	3.17	12.95	6.9	2.95	
Faberrebe	22.9	7.0	3.29	16.48	6.5	3.25	
Significance	**	**	**	***	***	***	
<i>Cultivars originating from Staatliches Weibauinstitut, Freiburg (^F) & Staatliche Lehr- und Versuchsanstalt, Weinsberg (^W), Germany (Baden-Württemberg)</i>							
Müller-Thurgau	17.8c	6.2c	3.17b	12.95b	6.9d	2.95b	
Holder ^W	20.7ab	7.3bc	3.24a	14.00a	7.5c	3.08a	
Juwel ^W	19.0bc	9.0a	2.91c	12.25b	8.4b	2.75d	
Nobling ^F	21.6a	7.9b	3.13b	14.40a	8.5b	2.85c	
Significance (white grapes)	***	***	***	***	***	***	
Spätburgunder 52-86 Fr.	19.1A	7.6A	3.16A	6.80	8.0C	3.21A	38.2C
Helfensteiner ^W	17.9B	8.1A	3.08B	7.00	9.9A	3.03B	55.9B
Heroldrebe ^W	18.1B	6.1B	3.23A	6.65	9.0B	3.01B	84.0A
Significance (red grapes)	*	***	***	NS	***	***	***
<i>Cultivars originating from Institut für Rebenzüchtung, Geisenheim, Germany (Rheingau)</i>							
Riesling clone 21B Weis	18.0c	9.5a	3.03c	12.10c	8.9b	2.82d	
Gm 6497-4	19.4b	8.0b	3.14b	14.25b	7.9c	3.02c	
Gm 676-2	22.2a	7.4b	3.24a	15.75a	7.2e	3.17a	
Gm 7117-10	20.2b	10.0a	2.99d	12.65c	9.6a	2.82d	
Gm 7116-26	22.2a	7.7b	3.17b	15.80a	7.5d	3.07b	
Significance	***	***	***	***	***	***	
<i>Cultivars originating from Bayerische Landesanstalt für Wein-, Obst- und Gartenbau, Würzburg-Veitshochheim, Germany (Franken)</i>							
Riesling clone 21B Weis	18.0b	9.5a	3.03	12.10c	8.9a	2.82d	
Cantaro	23.3a	5.7b	3.34b	16.45a	5.9c	3.17b	
Fontanara	19.7ab	6.1b	3.20c	13.80b	6.6b	2.98c	
Perle	17.2b	3.5c	3.63a	11.75c	5.0d	3.38a	
Rieslaner cl. 3	20.9ab	9.7a	3.11d	13.75b	9.1a	2.94c	
Significance	*	***	***	***	***	***	
<i>Hungarian muscat-flavored winegrape cultivars</i>							
Csabagyongye	17.6c	6.9c	3.25b	12.45b	5.9c	3.04b	
Kozma Palne Muscotaly	16.7d	7.1c	3.21c	11.45c	6.5b	3.00c	
Zefir	21.4a	7.4b	3.41a	15.40a	5.4d	3.23a	
Zengo	19.3b	10.3a	2.95d	12.20b	10.1a	2.78d	
Significance	***	***	***	***	***	***	
<i>Hungarian white winegrape cultivars and selections</i>							
Bianca	22.0	8.2	3.26	15.70	7.3	3.20	
Badacsony 10	22.3	11.0	3.05	15.45	10.6	3.03	
Significance	NS	**	***	NS	***	**	
<i>Red winegrape cultivars</i>							
Merlot	19.7ab	7.7c	3.10b	8.20d	10.5c	2.98d	103.7d
Agria	19.9ab	6.9d	3.37a	8.70b	9.9d	3.18b	325.2b
Michurinetz	23.2a	12.5a	2.99c	9.95a	12.6a	3.17b	651.7a
Regent	21.9ab	5.5e	3.40a	8.70b	8.6e	3.33a	630.3a
Zweigeltrebe	18.9b	6.4d	3.14b	6.95d	9.6d	2.87e	177.5c
Kozma 55	22.4ab	9.5b	3.15b	8.00c	11.4b	3.11c	143.0cd
Kozma 525	20.0ab	8.2c	3.11b	7.20d	11.0b	2.99d	323.0b
Significance	*	***	***	***	***	***	***

^zTitrateable acidity is expressed as tartaric acid in g·L⁻¹ (1.0 g·L⁻¹ = 1000 ppm).

NS, *, **, ***Nonsignificant or significant at $P \leq 0.05$, 0.01, or 0.001, respectively. Means followed by different letters are significant at $P \leq 0.05$, Duncan's multiple range test. Where both red and white winegrape cultivars appear within a table subsection, lowercase designations refer to white winegrapes, while uppercase designations refer to red winegrapes.

Fig. 1. Mean sensory profile of aroma descriptors for 1993 British Columbia wines produced from eight 'Riesling' alternative cultivars. ^{NS}, *, **, ***Nonsignificant or significant at $P \leq 0.05$, 0.01, or 0.001, respectively.

Fig. 2. Mean sensory profile of flavor descriptors for 1993 British Columbia wines produced from eight 'Riesling' alternative cultivars. ^{NS}, *, **, ***Nonsignificant or significant at $P \leq 0.05$, 0.01, or 0.001, respectively.

Fig. 3. Projection of wine aroma (lowercase) and flavor (uppercase) data from seven 'Riesling' alternative cultivars on principal components 1 (36.5% of variability) and 2 (23.9% of variability).

grams, plus 'Perle' from the Würzburg program, were included in this tasting. Most cultivars exceeded or equaled 'Müller-Thurgau' with respect to all aroma and flavor descriptors (Fig. 4). 'Faberrebe' was notable in terms of high intensity of floral/muscat, apple/pear, and fig/raisin aromas and flavors, as well as spicy flavor. 'Holder' was also noteworthy in terms of intensity of floral/muscat and apple/pear aromas. Other cultivars tended to display very similar aroma and flavor profiles (Fig. 4).

Hungarian white wine cultivars.

The four muscat-flavored cultivars ('Csabagyongye', 'Kozma Palne Muscotaly', 'Zefir', and 'Zengo') plus 'Bianca' and 'Badacsony 10' were selected for this tasting. All cultivars exceeded or equaled the standard 'Csabagyongye' in terms of all aroma and flavor attributes. 'Kozma Palne Muscotaly' and 'Zefir' were particularly notable in terms of their high intensity of muscat and apricot/peach aromas, while 'Zefir' also displayed high muscat,

cooked strawberry, and vegetal flavors (Fig. 5). Both 'Zengo' and 'Badacsony 10' were noteworthy in terms of high apricot/peach flavor.

Pinot noir-like cultivars. 'Spätburgunder' 52-86 Fr. was included as a standard in this tasting, along with 'Frühburgunder', 'Helfensteiner', 'Heroldrebe', and 'Samtröt'. Field performance of 'Frühburgunder' and 'Samtröt' are reported elsewhere (Reynolds, 1996a). All cultivars, with the exception of 'Frühburgunder', exceeded or equaled 'Spätburgunder' in terms of all aroma and flavor descriptors (Figs. 6, 7). Aroma profiles of the five cultivars were remarkably similar, however, and 'Frühburgunder' and 'Helfensteiner' were considerably less grassy and vegetal than the others (Fig 6). An aroma attribute described by the tasters as "animal-like" appeared to be less apparent in 'Frühburgunder' than the others. This confirms data from the 1995 tasting of the 'Pinot noir' clones in which 'Frühburgunder' was included; it tended to be the least intense in

all aroma and flavor descriptors compared to the other 'Pinot noir' clones (Reynolds, 1996a). 'Spätburgunder' had a tendency to be least intense in terms of cherry, berry, and currant aromas (Fig. 6). 'Helfensteiner' appeared noteworthy in terms of cherry, berry, and currant flavors, while 'Samtröt' was the most intensely colored wine, with the highest acidity and body, and most intense finish (Fig. 7).

Miscellaneous red cultivars. All cultivars exceeded or equaled the standard 'Merlot' in all aroma and flavor attributes (Figs. 8, 9). Noteworthy cultivars included 'Regent', with intense cherry and spicy aroma attributes, and both 'Michurinetz' and 'Kozma 55', with high currant and plum aromas (Fig. 8). The six cultivars had very similar flavor profiles (Fig. 9) but 'Michurinetz' was notable in terms of high berry and spicy flavors, body, and color. The standard 'Merlot' appeared to be least intense in the fruit flavors and color but most vegetal in flavor (Fig. 9).

Fig. 4. Mean sensory profile of aroma and flavor descriptors for 1993 British Columbia wines produced from several 'Müller-Thurgau' alternative cultivars. ns, *, **, **** Nonsignificant or significant at $P \leq 0.05$, 0.01, or 0.001, respectively.

Fig. 5. Mean sensory profile of aroma and flavor descriptors for 1993 British Columbia wines produced from several Hungarian muscat-flavored white wine cultivars. ns, *, **, **** Nonsignificant or significant at $P \leq 0.05$, 0.01, or 0.001, respectively.

Fig. 6. Mean sensory profile of aroma descriptors for 1993 British Columbia wines produced from several 'Pinot noir'-like cultivars. ^{ns}, *, **, ***Nonsignificant or significant at $P \leq 0.05$, 0.01, or 0.001, respectively.

Fig. 7. Mean sensory profile of flavor descriptors for 1993 British Columbia wines produced from several 'Pinot noir'-like cultivars. ^{ns}, *, **, ***Nonsignificant or significant at $P \leq 0.05$, 0.01, or 0.001, respectively.

Fig. 8. Mean sensory profile of aroma descriptors for 1993 British Columbia wines produced from seven miscellaneous red wine cultivars. ^{ns}, *, **, ***Nonsignificant or significant at $P \leq 0.05$, 0.01, or 0.001, respectively.

Fig. 9. Mean sensory profile of flavor descriptors for 1993 British Columbia wines produced from seven miscellaneous red wine cultivars. ^{ns}, *, **, ***Nonsignificant or significant at $P \leq 0.05$, 0.01, or 0.001, respectively.

Conclusions and grower benefits

The information compiled in this study and in the reports from the preliminary trial (BCMAFF, 1992, 1993) provides a comprehensive set of data that may benefit growers throughout North America. It has particular applicability to those regions in which *V. vinifera* cannot be grown, where late-maturing cultivars cannot consistently mature their fruit, and for growers with interest in growing grapes in the absence of pesticides. It also appears to be the first evaluation of most of these cultivars and selections in North America. The preliminary trial (BCMAFF, 1992, 1993) suggested that 37 of the original 85 cultivars included in the evaluation had commercial potential. These included five 'Chardonnay' clones and six 'Pinot noir' clones that are described elsewhere (Reynolds, 1996). Also among the original 37 were cultivars that have become established in the industry ('Auxerrois', 'Csabagyongye', 'Ehrenfelser', 'Merlot', 'Müller-Thurgau', 'Ortega', 'Schönburger', and 'Weissburgunder'). However, several other cultivars emerged from this trial with excellent potential from both a horticultural and commercial winemaking point of view. White wine cultivars considered noteworthy included several from Geisenheim ('Gm 6497-4', 'Gm 676-2', 'Gm 7116-26', and 'Gm 7117-10'), Weinsberg ('Juwel'), Würzburg ('Cantaro', 'Fontanara', and 'Rieslaner'), and Hungary ('Bianca', 'Badacsony 10', 'Kozma Palne Muscotaly', 'Zefir', and 'Zengo'). Red wine cultivars with potential were 'Pinot noir' alternatives 'Heroldrebe' and 'Helfensteiner', and the more deeply pigmented cultivars 'Regent', 'Michurinetz', 'Kozma 55', and 'Kozma 525'.

This study was also somewhat unique in its use of organic management techniques. Although disease incidence data were not collected, silicate sprays nonetheless adequately controlled powdery mildew, while oil and detergent provided acceptable control for leafhoppers. A major challenge was nitrogen management; the lack of sufficient quantity of organic nitrogen sources caused reductions in vine vigor and yields over the 3 years of this trial to a point where yields of some cultivars were noneconomic.

Optimization of nitrogen input was also cited as a major issue in organic management of vineyards in Italy (Malusa et al., 2004; Marengi, 2002); however, when organic nitrogen fertilizer was applied in adequate amounts [$300 \text{ kg} \cdot \text{ha}^{-1}$ (267.7 lb/acre) at 11% actual N], yields were not reduced, and berry polyphenols were increased over those from conventionally managed treatments. Growers considering organic viticulture are therefore urged to ensure that a consistent supply of organic nitrogen is available to sustain vine vigor and economic yields.

Literature cited

- Alleweldt, G. 1980. The breeding of fungus- and phylloxera-resistant grapevine varieties, p. 242–250. In: H.P. Olmo (ed.). Proc. 3rd Intl. Symp. Grape Breeding, Univ. of California Press, Davis.
- Alleweldt, G. and E. Dettweiler-Münch. 1992. The genetic resources of *Vitis*. Genetic and geographic origin of grape cultivars, their prime names and synonyms. Institut für Rebenzüchtung Geilweilerhof, Germany.
- Amerine, M.A. and C.S. Ough. 1980. Methods for the analysis of musts and wines. Wiley, New York.
- Barillère, J.M., A. Collas, C. Bougerey, and C. Palgé. 1995. Clonal selection in Champagne, p. 33–39. In: J. Rantz (ed.). Proc. Intl. Symp. Clonal Selection, Amer. Soc. Enol. Viticult., Davis, Calif.
- Becker, H. 1984. White grape varieties for cool climate, p. 46–62. In: D.A. Heatherbell, P.B. Lombard, F.W. Bodyfelt, and S.F. Price (eds.). Proc. 1st Intl. Symp. Cool Climate Viticult. Enol., Oregon State Univ. Tech. Publ. 7628.
- Becker, N. 1988. Performance of *Pinot noir* clones, p. 282–284. In: R.E. Smart, R. Thornton, S. Rodriguez, and J. Young (eds.). Proc. 2nd Intl. Symp. Cool Climate Viticult. and Oenology, N.Z. Soc. Viticult. Oenology, Auckland.
- Bernard, R. and M. Leguay. 1984. Clonal variability of *Pinot noir* in Burgundy and its potential adaptation under other cooler climates, p. 63–74. In: D.A. Heatherbell, D.A., P.B. Lombard, F.W. Bodyfelt, and S.F. Price (eds.). Proc. 1st Intl. Symp. Cool Climate Viticult. Enol., Oregon State Univ. Tech. Publ. 7628.
- Bettiga, L.J. 1995. Comparison of Merlot and Chardonnay clones in Monterey County: A preliminary report, p. 93–95. In: J. Rantz (ed.). Proc. Intl. Symp. Clonal Selection, Amer. Soc. Enol. Viticult., Davis, Calif.
- Boidron, R. 1995. Clonal selection in France. Methods, organization, and use, p. 1–7. In: J. Rantz (ed.). Proc. Intl. Symp. Clonal Selection, Amer. Soc. Enol. Viticult., Davis, Calif.
- British Columbia Ministry of Agriculture, Fisheries, and Food. 1992. Evaluation of European grape varieties. Summary Rpt. 1987–92. B.C. Min. Agr. Fish. Food, Agri-Food Reg. Subsidiary Agreement.
- British Columbia Ministry of Agriculture, Fisheries, and Food. 1993. Evaluation of European grape varieties. Suppl. Summary Rpt. 1987–92. B.C. Min. Agr. Fish. Food, Agri-Food Reg. Subsidiary Agreement.
- British Columbia Ministry of Agriculture, Fisheries, and Food. 1996. Grape production guide. B.C. Min. Agr. Fish. Food, Ext. Systems Branch, Victoria, B.C.
- Certified Organic Association of British Columbia. 2003. British Columbia certified organic production operation policies and management standards. Ver. 5. Book 2. Certified organic management standards. COABC, Vernon, B.C.
- Drought, B.G. and B. Stretch. 1996. Weather observations for 1995. Summaries and averages for 80 years of continuous recording. Misc. Publ., Agr. Agri-Food Canada, Res. Sta., Summerland, B.C.
- Hillebrand, W., H. Lott, and F. Pfaff. 1984. Taschenbuch der Rebsorten. Fachverlag Dr. Fraund GmbH.
- Kelley, C.C. and R.H. Spilsbury. 1949. Soil survey of the Okanagan and Similkameen Valleys, British Columbia. Rpt. No. 3, B.C. Survey, B.C. Dept. Agr., Victoria.
- Malusa, E., E. Laurenti, E. Ghibaudi, and L. Rolle. 2004. Influence of organic and conventional management on yield and composition of grape cv. Grignolino. Acta Hort. (In press.)
- Marengi, M. 2002. Biologico, una questione di cultura. Vignevini 6:51–53.
- Noble, A.C. 1988. Analysis of wine sensory properties, p. 10–28. In: H. Linskens and J. Jackson (eds.). Modern methods of plant analysis. Wine analysis, Vol. 6. Springer-Verlag, Berlin.
- Pool, R.M., T. Henick-Kling, G.E. Howard, B.K. Gavitt, and T.J. Johnson. 1995. Pinot noir clonal research in New York, p. 45–51. In: J. Rantz (ed.). Proc. Intl. Symp. Clonal Selection, Amer. Soc. Enol. Viticult., Davis, Calif.
- Price, S.F., P.B. Lombard, and B.T. Watson. 1988. Pinot noir clones and their effects on cluster morphology and grape composition, p. 279–281. In: R.E. Smart, R. Thornton, S. Rodriguez, and J. Young (eds.). Proc. 2nd Intl. Symp. Cool Climate Viticult.

Oenology, N.Z. Soc. Viticult. Oenology, Auckland.

Price, S.F. and B.T. Watson. 1995. Preliminary results from an Oregon Pinot noir clonal trial, p. 40–44. In: J. Rantz (ed.). Proc. Intl. Symp. Clonal Selection, Amer. Soc. Enol. Viticult., Davis, Calif.

Reynolds, A.G. 1996a. Einfluss von Klonen auf die Sensorik von Spätburgunder und Chardonnay. Die Winzer Zeitschrift 11(4):28–30.

Reynolds, A.G. 1996b. Alternative control measures for powdery mildew. Vineyard Winery Mgt. 22(3):25–26, 28, 42–43, 46.

Reynolds, A.G., P.L. Sholberg, D.A. Wardle, and P. Haag. 1996. Use of potassium silicate for the control of powdery mildew (*Uncinula necator*) in *Vitis vinifera* cultivar Bacchus. Amer. J. Enol. Viticult. 47:421–428.

Watson, B.T., P.B. Lombard, S.F. Price, M. McDaniel, and D. Heatherbell. 1988. Evaluation of *Pinot noir* clones in Oregon, p. 276–278. In: R.E. Smart, R. Thornton, S. Rodriguez, and J. Young (eds.). Proc. 2nd Intl. Symp. Cool Climate Viticult. Oenology, N.Z. Soc. Viticult. Oenology, Auckland.

Wolf, T.K. and M.K. Miller. 2001. Crop yield, fruit quality, and winter injury of 12 red-fruited wine grape cultivars in Northern Virginia. J. Amer. Pomol. Soc. 55:241–250.

Wolf, T.K. and M.K. Warren. 2000. Crop yield, grape quality, and winter injury of eight red-fruited wine grape cultivars in Northern Virginia. J. Amer. Pomol. Soc. 54:34–43.

Wolpert, J.A. 1995. Evaluation of wine-grape clones in coastal California: current activities and future prospects, p. 74–80. In: J. Rantz (ed.). Proc. Intl. Symp. Clonal Selection, Amer. Soc. Enol. Viticult., Davis, Calif.