Variety Trials

Evaluation of Winegrapes in British Columbia: 'Chardonnay' and 'Pinot noir' Clones

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ADDITIONAL INDEX WORDS. *Vitis*, breeding, winemaking, sensory analysis

SUMMARY. Eighty-five cultivars, selections and clones from European winegrape (*Vitis* spp.) breeding and selection programs were evaluated between 1993 and 1995 in a randomized complete-block experiment. These included *Vitis vinifera* clones from France as well as Freiburg, Geisenheim, and Weinsberg, Germany. Small yield and fruit composition differences were found amongst the 'Chardonnay' clones. The standard Prosser clone produced wines with highest earthy aroma and acidity and

with lowest perfumy aroma, body and finish; Dijon clones 76 and 96 were most perfumy and least vegetal. 'Pinot noir' clones also differed somewhat in terms of yield and fruit composition; 'Samtröt', 'Gamay Beaujolais', and clone Q1342-01 were amongst the most highly colored clones. These clones also tended to have the most intense berry and currant aromas as well as berry, cherry, and currant flavors. These aforementioned clones appear to be highly adaptable to viticultural regions where low heat units during fruit maturation presently limit industry growth.

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. Many intraspecific *V. vinifera* cultivars and selections have also been bred to add to the diversity of the cultivar profile within various winegrowing regions of the world, for example, 'Ehrenfelser' ('Riesling' x 'Sylvaner', 1929) from the breeding program in Geisenheim, Germany, and 'Scheurebe' ('Riesling' x 'Sylvaner', 1911) from the breeding station at Alzey (Becker, 1984). As an adjunct to these programs, ongoing clonal selection programs for *V. vinifera* focus upon cultivar improvement through selection of superior clones. 'Riesling', 'Chardonnay', and 'Pinot noir' are three cultivars for which clonal selection has been an ongoing priority (Becker, 1984; Bernard and Leguay, 1984; Boidron, 1995).

As new vineyard regions are be-

ing established throughout North America, grapegrowers are increasingly demanding more choices in planting material. In the coastal regions of the Pacific Northwest of North America, lack of heat units during fruit maturation is usually the limiting factor. Little or no information is available from these regions documenting the performance of various European cultivars, selections, and clones in specific regions of North America. Notable exceptions are the clonal trials on 'Pinot noir' in Oregon (Price et al., 1988; Price and Watson, 1995; Watson et al., 1988) and NY (Pool et al., 1995), and those in California on numerous cultivars including 'Cabernet Sauvignon', 'Chardonnay', 'Merlot', and 'Zinfandel' (Bettiga, 1995; Wolpert, 1995).

Since 1990, many French clones of 'Chardonnay' and 'Pinot noir' have become available to North American grape growers. Also, many viticultural regions outside the traditional wine producing areas have become established throughout the U.S. and Canada, and these industries have created a demand for new cultivars and clones that are adaptable to the unique climatic conditions present in these regions. The objective of this study was to evaluate a large collection of cultivars and selections (both interspecific and intraspecific *V. vinifera*) and *V. vinifera* clones in terms of field performance, fruit composition, and wine sensory attributes with the ultimate goal of introducing to the industry those that performed best viticulturally and enologically. Performance of German and Hungarian cultivars and selections is reported elsewhere (Reynolds et al., 2004).

Materials and methods

ENVIRONMENTAL CONDITIONS. Cultivars and clones were evaluated at the Pacific Agri-Food Research Centre, Summerland, B.C. The site was situated in the Okanagan Valley, which is considered an arid continental climate. Elevation was 454 m (1490 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

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was -15.7°C (3.74°F), which occurred in Feb. 1994. 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 (*Daktulosphaira vitifoliae*) 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 1.8×2.7 m (6×9 ft; vine $\times$ row), trained to 0.6-m-high (24 inches) bilateral cordons, and pruned to enough two-node spurs to provide 16.4 shoots/m row (5 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 $4.54\text{ L}\cdot\text{h}^{-1}$ (1.2 gal/h). Irrigation began each season at 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 d [$18.17\text{ L}/\text{vine}$ ($4.8\text{ gal}/\text{vine}$) per d, or $36,217\text{ L}\cdot\text{ha}^{-1}$ ($3872\text{ gal}/\text{acre}$)].

Pest control was done according to local recommendations from 1988–92 (BCMAFF, 1996) and organically thereafter. A growing organic movement has been evident in British Columbia since the late 1980s, and this trial was regarded as an opportunity to gain some experience with organic viticulture across a wide range of cultivars. During 1993–95, powdery mildew (*Uncinula necator*) was controlled by $1000\text{ mg}\cdot\text{L}^{-1}$ (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, Ont.) 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, 1996). 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 non-certified product used during the course of the trial. No nitrogen was applied during 1993–95 due to the non-availability of sufficient quantities of any 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 designed. Those comprising the ‘Chardonnay’ and ‘Pinot noir’ clones are described herein. The ‘Chardonnay’ clones included: three Dijon clones (76, 95, and 96); Q1342-03, an accession, originally from France, from the collection at the Centre for Plant Health, Saanichton, B.C., and; the ‘Prosser’ clone, origin unknown, but frequently linked to the Washington State University Research and Extension Center, Prosser. The ‘Pinot noir’ clones included: two Dijon clones (164 and 375); Spätburgunder 52-86 Fr (from Freiburg, Germany); ‘Samtröt’ (a clone of ‘Pinot Meunier’ from Weinsberg, Germany); ‘Blauer Frühburgunder’, an early-maturing clone of ‘Pinot noir’ (selected at Geisenheim, Germany); Q1342-01, an accession, originally from France, from the collection at the Centre for Plant Health, Saanichton, B.C., and; ‘Gamay Beaujolais’, a large-berried ‘Pinot noir’ clone. The complete list of cultivars, selections and clones evaluated in this trial is found in Reynolds et al. (2004).

YIELD COMPONENTS. Harvest date was based annually on physiological maturity, determined by tasting random berry selections every 48 h. Harvest 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). Yield per vine was recorded at harvest. A random 100-berry sample was taken from each treatment replicate to determine berry weight and for subsequent chemical analysis. ‘Chardonnay’ clones were harvested between 15 and 17 Oct. 1993 and on similar dates in 1994 and 1995. ‘Pinot noir’ clones were harvested on 22 Sept. (‘Blauer Frühburgunder’) and 18 Oct. 1993 (all others), and on similar dates in 1994 and 1995.

BERRY COMPOSITION. The berry samples were juiced in a commercial centrifugal juicer, the suspended solids were separated from the clear juice, and °Brix [hereinafter referred to as percent soluble solids (percent SS)] 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 the aid of a Brinkmann automatic titrating ensemble (Metrohm, Herisau, Switzerland).

WINEMAKING, MUST AND WINE COMPOSITION, SENSORY ANALYSIS. *Winemaking.* Based on encouraging preliminary data collected during the pilot project in 1991 (BCMAFF, 1992, 1993), all the ‘Chardonnay’ and ‘Pinot noir’ clones were chosen for winemaking in 1993. All fruit from each treatment replicate was retained at harvest in 1993 for winemaking. Grapes were typically stored at 2°C (35.6°F) for 24 h, crushed in a Garolla crusher-de-stemmer, 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 $25\text{ mg}\cdot\text{L}^{-1}$ free sulfur dioxide (SO_2), settled at 2°C for 24 h, and racked into 20-L glass carboys. ‘Chardonnay’ musts were inoculated with EC1118 (*Saccharomyces bayanus*; Lallemant Corp., Montreal, Quebec) yeast. Untoasted American oak chips [$1\text{ g}\cdot\text{L}^{-1}$ (0.13 oz/gal)] were added to all ‘Chardonnay’ fermentations at the

start of fermentation in order to more closely approximate commercially available wines. Fermentations were carried out without chaptalization to dryness at 15 °C (59.0 °F). Fruit from each 'Pinot noir' clone treatment replicate was 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. Malo-lactic fermentation (MLF) was not performed because of concern that MLF might have produced aromas and flavors in the wines that were not reflective of the clones themselves. Before bottling, fermentations from adjacent field blocks (i.e., blocks 1+2; blocks 3+4) were blended together (mixed) to provide two tasting replicates. Wines were thereafter filtered through a 0.45-µm (pore size) 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 'Chardonnay' wine replicates immediately after pressing, and from all 'Pinot noir' 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 of the must, and TA and pH of the musts and wines were determined as previously described for the berry samples. Anthocyanins in the 'Pinot noir' 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 after 12 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 percent correct responses in triangle tests in several other related experiments). Aroma descriptors and retronasal aroma/tactile (flavor) descriptors

Table 1. Descriptors and standards used for sensory analysis of wines produced from 'Chardonnay' and 'Pinot noir' clones at Summerland, B.C., in 1993.

Name of descriptor	Details of reference preparation
<i>'Chardonnay' clones^a</i>	
Green apple/pear	1 mL (0.034 fl oz) imitation apple extract 1659 ^y
Melon/fruity	1 mL natural + artificial melon extract 138217 ^z
Perfumy/floral	1 drop linalool
Fig/raisin/dried fruit	1 mL natural date type extract SPL-3333 ^y
Vegetal/bell pepper	1 mL vegetable extract 2M-44444 ^w
Grassy/hay	250 mL (8.5 fl oz) 1993 experimental 'Semillon' wine
Earthy	1 mL imitation mushroom extract F-6327 ^y
Cedar/pine/resin	1 mL spruce beer extract 4691 ^y
Oak/vanillin	1 mL oak chip extract 13394 ^x
<i>'Pinot noir' clones^a</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 ^y
Plum/prune	350 mL (11.8 fl oz) 1981 experimental golden plum wine
Grassy/hay	300 mL (10.1 fl oz) 1993 experimental 'Semillon' wine
Vegetal/bell pepper	1 mL vegetable extract 2M-44444 ^w
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

^aVolumes indicated were added to 0.5 L (16.9 fl oz) of 1993 experimental 'Chardonnay' wine.

^yGivaudin Ltd., Atlanta, Ga.

^zAlex Fries, Inc., Cincinnati, Ohio.

^wQuest International Nederland PV, Naarden, The Netherlands.

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

^yQuantities indicated were added to 1 L (33.8 fl oz) of experimental 1987 'Gamay noir' wine.

were chosen by consensus following evaluation of numerous aroma and flavor samples (Table 1) and examples of wines produced from the 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 aroma only, 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 clone in separate sessions. A 100-mm-line (3.9 inches) scoresheet anchored at and quantified between 0 (low) and 100 (high) was used.

STATISTICAL ANALYSIS. All data were analyzed using the SAS statistical package (SAS Institute, Cary, N.C.). The General Linear Models Procedure was utilized for analysis of variance (ANOVA). Sensory data were subjected to both ANOVA and principal components analysis (PCA). PCA is a multivariate statistical technique that uses correlation coefficients to elucidate the nature of shared variability

amongst several measured chemical 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 is 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.

Table 2. Yield and berry composition of several 'Chardonnay' and 'Pinot noir' clones evaluated at Summerland, B.C., in 1993–95. Boldfaced clones within each table subsection are commercial standards.

Cultivar and clone	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
'Chardonnay' clones															
Prosser	12.8a	5.9	3.4ab	1.15	1.05b	1.16c	19.6b	25.3d	27.0c	9.6a	9.8a	10.0a	3.10	3.11c	3.24c
76 Dijon	11.0b	6.3	2.4ab	1.17	1.02c	1.16c	20.7ab	26.0b	25.3d	8.6ab	8.0e	7.7d	3.10	3.19a	3.20d
95 Dijon	14.5a	5.6	3.2ab	1.16	0.88	1.16c	21.3a	26.5a	27.1b	8.6ab	8.6c	7.5e	3.12	3.16b	3.25b
96 Dijon	13.0ab	7.2	5.0a	1.05	1.12a	1.25a	21.8a	25.7c	25.1e	7.8b	8.2d	8.2b	3.15	3.16b	3.25b
Q1342-03															
Saanichton	11.8ab	5.1	1.8b	1.2	0.90d	1.19b	21.5a	24.5e	27.9a	8.3ab	8.8b	7.9c	3.10	3.09d	3.33a
Significance	*	NS	*	NS	***	***	*	***	***	*	***	***	NS	***	***
'Pinot noir' clones															
'Spätburgunder'															
52-86 Fr	10.6	4.1ab	6.1b	1.13	0.84g	0.86g	20.0ab	27.8a	25.8b	8.8a	7.2c	8.2d	3.15d	3.27c	3.19f
'Blauer															
Frühburgunder'	6.9	8.3a	2.8b	0.99	0.98b	0.97f	19.6b	22.8f	27.7a	6.5d	6.1e	6.8f	3.34a	3.34a	3.50a
'Gamay															
Beaujolais'	11.9	7.8ab	5.0b	1.16	1.11a	1.17a	21.2ab	27.4c	23.4e	8.5ab	6.1e	8.8c	3.20cd	3.25d	3.17g
'Samtröt'	11.8	5.7ab	3.7b	1.07	0.87e	1.15c	22.0ab	26.5e	23.1f	7.2cd	7.2c	10.5a	3.28ab	3.30b	3.26d
164 Dijon	7.6	7.1ab	14.0a	1.02	0.90d	1.16b	20.0ab	26.5e	23.5d	8.1abc	7.4b	9.2b	3.24bc	3.25d	3.22e
375 Dijon	5.1	2.7b	0.7b	1.16	0.95c	0.97e	22.8ab	27.5b	25.8b	8.9a	8.5a	7.4e	3.22cd	3.09e	3.28c
Q-1342-01	6.7	6.3ab	0.5b	1.09	0.86f	1.04d	23.4a	27.0d	25.0c	7.5bcd	7.1d	6.6g	3.29ab	3.25d	3.33b
Significance	NS	*	**	NS	***	***	*	***	***	***	***	***	***	***	***

^a1.0 t·ha⁻¹ = 0.45 ton/acre; 1.00 g = 0.035 oz; 1.0 g·L⁻¹ = 1000 ppm; titratable acidity is expressed as g·L⁻¹ tartaric acid.

*, **, ***, 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.

Results and discussion

YIELD AND BERRY COMPOSITION.

'Chardonnay' clones. Yields of 'Chardonnay' clones declined over the 3 years of the trial due, presumably, to reduction in vine size caused by low nitrogen. Small differences were observed between the 'Chardonnay' clones in terms of yield and berry composition (Table 2). Yields differed amongst clones in 1993 and 1995; yield of Q1342-03 (Saanichton) tended to be less than that of other clones, and was reduced to 15% of its yield in 1993 (Table 2). Clone 96 tended to be amongst the highest-yielding and maintained a yield of 38% of its 1993 level after 3 years of organic management (Table 2). Berry weights, percent SS, TA, and pH varied amongst clones each season (Table 2). Clone 96 produced the largest berries in 2 of 3 years, while clone 95 berries were the smallest (Table 2). Soluble solids tended to increase in 1994 and 1995 in response to the reduction in yield per vine. Soluble solids showed no consistent pattern with respect to clone; clones 95, 96, and Q1342-03 were amongst those with the highest percent SS (Table 2). TA tended to be highest each year in berries from

Prosser clone, but other clones were not consistent with respect to each other (Table 2). Berry pH showed no consistent pattern with respect to clones (Table 2).

'Pinot noir' clones. No yield differences were observed between 'Pinot noir' clones in 1993, but yield varied amongst clones in 1994 and 1995 (Table 2). 'Gamay Beaujolais' tended towards the highest yields in 1993-94 and maintained a yield of 42% of its 1993 level after three seasons of organic management (Table 2). 'Spätburgunder' 52-86 Fr had yields similar to 'Gamay Beaujolais' and maintained a yield of 57% of its 1993 level after three seasons under organic management (Table 2). Clone 164 produced the highest yields in 1995, despite 3 years of organic management that involved no nitrogen inputs (Table 2). Clone 375 was the lowest-yielding clone despite its reputation to the contrary under Burgundian conditions (Barillère et al., 1995). In fact, clone 375 was reduced to 13.7% of its 1993 level after 3 years of organic management (Table 2). Both clones 375 and Q-1342-01 were reduced to <15% of their 1993 yields by the 1995 season, due primarily to low vine size resulting from a lack of nitrogen input. Clones differed amongst

each other with respect to berry weight and composition each season (Table 2). 'Gamay Beaujolais' had the highest berry weight each season, while the lowest berry weights in 1994-95 were found for 'Spätburgunder' clone 52-86 Fr. No consistent patterns were detected among clones with respect to percent SS, although 'Frühburgunder' was lowest in 1993 and 1994 (Table 2). 'Frühburgunder' also had lowest the TA in 1993-94 and the highest pH in 1993-95 (Table 2).

These results partially support those of Pool et al. (1995), who found that 'Gamay Beaujolais' to be high-yielding under New York conditions, and 'Spätburgunder' (clone unspecified) to be low-yielding. Both 'Gamay Beaujolais' and clone 375 were also considered high-yielding clones under Oregon conditions (Price and Watson, 1995). Becker (1988) found 'Spätburgunder' 52-86 Fr. to be a low-yielding clone relative to three others, with small berries and low percent SS.

MUST AND WINE COMPOSITION. **'Chardonnay' clones.** The Prosser clone tended towards the lowest must percent SS, the highest must and wine TA, and the lowest ethanol (Table 3). Clone 96 was highest in must percent SS, and must and wine pH,

Table 3. Must and wine composition of several 'Chardonnay' and 'Pinot noir' clones, evaluated at Summerland, B.C., 1993. Boldfaced clones within each table subsection are commercial standards.

Cultivar and clone	Must composition			Wine composition			
	Soluble solids (%)	Titrateable acidity (g·L ⁻¹) ^z	pH	Ethanol (%)	Titrateable acidity (g·L ⁻¹) ^z	pH	Total anthocyanins after press [mg·L ⁻¹ (ppm)]
<i>'Chardonnay' clones</i>							
Prosser	19.2b	8.8a	3.07ab	12.15b	8.6a	3.00b	
76 Dijon	20.5ab	8.1b	3.06ab	13.35a	7.9bc	2.97c	
95 Dijon	21.2ab	7.9b	3.08ab	13.90a	7.6cd	3.02a	
96 Dijon	21.5a	7.7b	3.09a	14.00a	7.5d	3.03a	
Q1342-03	21.1ab	8.0b	3.05b	13.75a	8.0b	2.98bc	
Significance	*	*	*	***	***	***	
<i>'Pinot noir' clones</i>							
'Spätburgunder' 52-86 Fr	19.1	7.6abc	3.16c	6.80c	8.0e	3.21c	38.2bc
'Blauer Frühburgunder'	19.5	5.9d	3.48a	8.05ab	6.7g	3.31a	23.3c
'Gamay Beaujolais'	20.1	8.1a	3.17c	6.95bc	8.5c	3.16d	51.3ab
'Samtröt'	21.0	6.4cd	3.28b	8.45a	7.6f	3.30a	44.5ab
164 Dijon	19.2	7.7abc	3.17c	7.05bc	8.1d	3.19cd	35.2bc
375 Dijon	22.1	8.0ab	3.18c	7.40abc	9.0b	3.19cd	45.7ab
Q-1342-01	22.8	6.7bcd	3.28b	6.90bc	9.2a	3.25b	57.2a
Significance	NS	***	***	*	***	***	**

^zTitrateable acidity is expressed as g·L⁻¹ tartaric acid; 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.

and lowest in wine TA, while clones 76 and Q1342-03 tended towards lower pH.

'Pinot noir' clones. Clones did not differ in terms of must percent SS (Table 3), although clones 375 and Q1342-01 tended to be clones with high percent SS. The standard 'Spätburgunder' 52-86 Fr., clones 164, 375 and Q1342-01, and 'Gamay Beaujolais' were the group of clones that tended towards highest must TA, and lowest must and wine pH (Table 3). 'Frühburgunder' and 'Pinot Meunier' clone 'Samtröt' were highest in ethanol, lowest in must and wine TA, and highest in must and wine pH (Table 3). 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. Clone Q1342-01 produced wines with highest anthocyanin concentration, while 'Frühburgunder' wines were lowest in anthocyanins (Table 3). Anthocyanins increased from 23.3–57.2 mg·L⁻¹ at pressing (Table 3) to 62.9–91.9 mg·L⁻¹ at bottling, but no differences were apparent amongst the clones at bottling (data not shown).

SENSORY ANALYSIS. 'Chardonnay' clones. The Prosser clone produced wines that were highest in yellow color,

earthy aroma, and acidity, and lowest in perfumy aroma, body, and intensity of finish (Fig. 1). Clone 95 was lowest in yellow color and highest in grassy aroma, while clone 76 had most vegetal aroma (Fig. 1). Use of PCA showed that melon, perfumy and apple aromas were highly correlated with perfumy, and melon and oak flavors, as well as perceptions of sweetness, alcohol, body, and intensity of finish; these eigenvectors were all oriented along PC1 (Fig. 2). Color, intensity of vegetal, earthy, cedar, and oak aromas, vegetal and earthy flavors, tannin and acidity were inversely correlated with the aforementioned group of descriptors. The Prosser clone and to a lesser extent clone 76 were most closely described by the group of descriptors to the left of PC2; these clones were also low in perfumy aroma, melon and perfume flavor, body, finish, and alcoholic character. Dijon 76 wines tended towards higher cedar and oak aromas, earthy and vegetal flavors, and tannin. Clones 95, 96, and Q1342-03 appeared to be described by fruity aromas and flavors (Fig. 2).

'Pinot noir' clones. The standard 'Spätburgunder' 52-86 Fr. tended to be lowest in cherry, berry, and anise aromas but did not differ from the other clones in other aroma attributes (Fig. 3). Clones 164 and 375 were highest in

cherry and berry aromas, while 'Gamay Beaujolais' had the most currant aroma. Q1342-01 was most intensely colored and both 'Spätburgunder' and 'Frühburgunder' were least intense (data not shown). 'Spätburgunder' was also lowest amongst the clones in cherry, berry, and currant flavors, as well as body, bitterness, astringency, and intensity of finish (Fig. 4). Highest cherry and berry flavors, body, and intensity of finish were found in clone Q1342-01 wines, while clone 164 wines had the least pepper flavor (Fig. 4).

PCA revealed that grassy, vegetal, plum, and candy aromas, along with plum flavor, were correlated with each other along PC1, and inversely correlated with cherry, berry, and currant aromas and flavors, color, body, and finish (Fig. 5). The standard 'Spätburgunder' 52-86 Fr. was high in vegetal, plum, and grassy aromas, and plum flavor, and tended to be low in most of the fruity aromas and flavors, as well as finish, body, and tannin. 'Frühburgunder' was similarly characterized but its position relative to the other clones indicated that it was low in all sensory attributes. Clones 164, 375, and Q1342-01 tended to be highest in cherry and berry aromas, as well as currant and berry flavors, body, finish, and tannin. They were also low in plum, grassy, and vegetal aromas, as

Fig. 1. Mean sensory profile of aroma (lowercase) and flavor (uppercase) descriptors for wines produced in 1993 at Sumnerland, B.C., from five different 'Chardonnay' clones: Prosser (Wash.); ENTAV (Dijon, France) 75, 95 and 96; Saanichton (B.C.) Q1342-03. ^{NS}, ^{*}, ^{**}, ^{***} Nonsignificant or significant at $P \leq 0.05$, 0.01, or 0.001, respectively.

Fig. 2. Projection of wine aroma (lowercase) and flavor (uppercase) data from five 'Chardonnay' clones on principal components 1 (52% of variability) and 2 (18% of variability). Clones and their origins were: Prosser (Wash.); ENTAV (Dijon, France) 75, 95 and 96; Saanichton (B.C.) Q1342-03.

Fig. 3. Mean sensory profile of aroma descriptors for wines produced in 1993 at Summerland, B.C., from seven different 'Pinot noir' clones: 'Spätburgunder' 52-86 Fr (Freiburg, Germany); 'Blauer Frühburgunder' (Ingelheim, Germany); 'Gamay Beaujolais' (origin unknown); 'Samtröt' (Weinsberg, Germany); ENTAV (Dijon, France) 164 and 375; Saanichton (B.C.) Q1342-01. ^{NS}, ^{*}, ^{**}, ^{***} Nonsignificant or significant at $P \leq 0.05$, 0.01, or 0.001, respectively.

Fig. 4. Mean sensory profile of flavor descriptors for wines produced in 1993 at Summerland, B.C. from seven different 'Pinot noir' clones: 'Spätburgunder' 52-86 Fr (Freiburg, Germany); 'Blauer Frühburgunder' (Ingelheim, Germany); 'Gamay Beaujolais' (origin unknown); 'Samtröt' (Weinsberg, Germany); ENTAV (Dijon, France) 164 and 375; Saanichton (B.C.) Q1342-01. ^{NS}, ^{*}, ^{**}, ^{***} Nonsignificant or significant at $P \leq 0.05$, 0.01, or 0.001, respectively.

Fig. 5. Projection of wine aroma (lowercase) and flavor (uppercase) data from seven 'Pinot noir' clones on principal components 1 (34% of variability) and 2 (23% of variability). Clones and their origins were: Spätburgunder' 52-86 Fr (Freiburg, Germany); 'Blauer Frühburgunder' (Ingelheim, Germany); 'Gamay Beaujolais' (origin unknown); 'Samtröt' (Weinsberg, Germany); ENTAV (Dijon, France) 164 and 375; Saanichton (B.C.) Q1342-01.

well as plum flavor. 'Gamay Beaujolais' and 'Samtröt' were best characterized by currant, pepper, and anise aromas, as well as vegetal, cherry, and pepper flavors, and most bitterness. They also tended to have least candy aroma (Fig. 5).

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 also appears to be the first clonal evaluation trial in an arid continental climate under irrigation. Among 'Chardonnay' clones, 76, 95, and 96 performed well horticulturally, enologically, and sensorially. The Prosser clone proved to be a high-acid, vegetal-flavored clone for which planting should be discouraged. 'Pinot noir' clones were more variable; 'Blauer Frühburgunder' appeared to be very early maturing but lacked aroma and

flavor. 'Spätburgunder' 52-86 Fr. produced wines that were high in vegetal characteristics, which are considered undesirable from a winemaking standpoint. Clones 164, 375, and Q1342-01, as well as 'Gamay Beaujolais' and 'Samtröt' all demonstrated desirable sensory characteristics that would warrant their planting.

This study was also somewhat unique in its use of organic management techniques. It therefore has particular applicability to those arid regions west of the Rocky Mountains in which *V. vinifera* can be grown in the absence of pesticides. Silicate sprays controlled powdery mildew, while oil and soap 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. 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 was applied in adequate amounts [300 kg·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.

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