Best combiners during 40 years of breeding *Vitis* cultivars resistant to Pierce's disease

J. A. Mortensen and L. H. Stover

University of Florida, IFAS, Central Florida Research and Education Center, Leesburg, Florida 34748, USA

S u m m a r y : By breeding for resistance to Pierce's disease in *Vitis* we have obtained useful cultivars that can be grown productively in areas formerly considered unsuitable for grape production. Reviewing the most successful recombinants from crosses made between 1945 and 1984, 6 *Vitis* clones were prominent foundation parents among those tested as primitive resistant germplasm: *V. aestivalis*, ssp. *smalliana* cvs Fla. 43-47 and Fla. 449, *V. aestivalis* ssp. *simpsoni* cvs Pixiola and Fla. 451, and *V. shuttleworthii* cvs Haines City and Kissimmee. The best combiners for productivity, fruit size, and high quality were PD susceptible cultivars Aurelia, Carolina Blackrose, Cardinal, Exotic, Golden Muscat, and Villard blanc. The best combiners for seedlessness and early ripening were susceptible cultivars Lakemont and Perlette. Selection for resistance to PD required 7 or more years each generation for exposure of seedlings to PD-carrying vectors. Inbreeding was detrimental to vine vigor but good combiners were selected among inbred progeny which were more homozygous for disease resistance. Subsequent crosses of these inbreds to large-fruited, high-quality cultivars resulted in some recombinants with restored vigor and superior traits such as Blanc Du Bois.

K e y w o r d s : Pierce's disease, bacterium, Vitis, variety of vine, germplasm, resistance, breeding, inbreeding, parents, Florida, USA.

Introduction

Pierce's disease (PD) is a vascular disease of *Vitis* caused by the bacterium *Xylella fastidiosa* (Wells *et al.* 1987). PD is the major limiting factor to having long-lived and productive vineyards in Florida and the Coastal Plain areas of South Carolina, Georgia, Alabama, Mississippi, Louisiana, and Texas (Hopkins and Adlerz 1988). Resistance to PD was found in *Vitis* species native to Florida (Mortensen *et al.* 1977). Since 1945 a grape breeding program has been under way at Central Florida Research and Education Center, Leesburg, to incorporate this native PD resistance into viticulturally acceptable cultivars (Stover 1960). The purpose of this paper is to review the most successful recombinants from crosses made between 1945 and 1984 and to emphasize the best parental combinations used in the program.

Materials and methods

Sources of resistance to PD were found growing naturally in the woodlands of Florida, and were collected in 1941 and 1942 (Loucks 1942). Clones of the following Florida species were propagated from their native habitat to a vineyard located west of Leesburg where their longevity and health could be observed: *Vitis aestivalis* Michx. ssp. *simpsoni* Munson, *V. aestivalis* ssp. *smalliana* Bailey, *V. rufotomentosa* Small, *V. shuttleworthii* House, *V. sola* Bailey, *V. vulpina* L., *V. rotundifolia* Michx. and *V. munsoniana* Simpson.

Crosses made by Loucks during the 1930s using small-berried wild species as female parents and larger berried cultivars as male parents produced all small-berried progeny of low quality (Loucks 1938). *V. shuttleworthii* had larger berries, but when crossed the F_1 hybrids had small clusters. By 1945 a cross was made by Stover between Pixiola *(V. aestivalis* ssp. *simpsoni)* and Golden Muscat which produced 20 promising seedlings. Pixiola was collected by Loucks as a non-pigmented clone with fruit that was sweet but green-colored when ripe (Stover 1951).

Crosses between 1945 and 1984 were made with the objective of combining native disease resistance derived from Florida native grapes with acceptable fruit size and quality from superior

Table 1: Clones resistant to Pierce's disease (PD) used as parents in the first generation of breeding

Native species classification	Sex	Parental clone
Vitis aestivalis Michx. ssp. *simpsoni*	f	Pixiola
Vitis aestivalis Michx. ssp. *simpsoni*	f	Fla. 451
Vitis shuttleworthii House	f	Haines City
Vitis shuttleworthii House	m	Kissimmee
Vitis aestivalis ssp. *smalliana*	f	Fla. 43-47
Vitis aestivalis ssp. *smalliana*	f	Fla. 449

Table 2: First generation of crosses with *Vitis aestivalis* MICHX. ssp. *simpsoni* MUNSON and *V. shuttleworthii* HOUSE

Year of cross	Combination	Resistant progeny selected	Main uses[z]
1945	Pixiola x Golden Muscat	W381, W382	B
		Lake Emerald	WW
1950	Fla. 451 x Golden Muscat	W1001	B
1949	*V. shuttleworthii* open-poll.	Mantey	B
1961	Haines City x Alden	13B-5	RS
		13C-12	RS
1973	Haines City x Ark. 1105	BD7-75	B
1979	Villard Blanc x Kissimmee	CA8-15	RW

[z]Uses: B = breeding; RS = rootstock; RW = red wines; WW = white wine.

cultivars (STOVER 1960; MORTENSEN *et al.* 1977). Seedlings were planted 2.5 ft apart in a single-wire trellis vineyard at Leesburg and were fruited to determine which were usable recombinants. Individual plant performance was recorded for sex, budbreak, vine vigor, disease resistance, longevity, fruit size and quality (including seedlessness), productivity, and earliness. Natural infection from PD vectors was usually adequate to screen for resistance to PD while seedlings grew and fruited. Selections were propagated by hardwood cuttings for a second test at wider spacing (2.3-3 m in row). Crosses made each year between 1945 and 1984 were reviewed for progeny performance to determine which combinations produced outstanding recombinants.

Results and discussion

Many selections that initially were outstanding succumbed in later years to PD or fungus diseases or else became mediocre in fruit quality, productivity, or vine vigor. Selection for resistance to PD was found to be necessary each generation through natural exposure of seedlings for 7 or more years to PD-carrying vectors. 7-10 years are thus advisable before naming and release of a selection.

Table 3: First generation of crosses with *Vitis aestivalis* MICHX. ssp. *smalliana* BAILEY

Year of cross	Combination	Resistant progeny selected	Main uses[z]
1948	Fla. 43-47 x Golden Muscat	W716	B
1948	Fla. 43-47 x Niagara	Tampa	RS
1950	Fla. 43-47 x Caco	Blue Lake	JL
1963	Fla. 43-47 x Concord	E12-59	B, JU
1977	Fla. 43-47 x Aurelia	BD5-67	B
		BD8-43	RW
1977	Fla. 43-47 x Carolina	BD10-51	B
	Blackrose	CB9-23	RW
1977	Fla. 43-47 x Dunstan 236	AD1-115	RW
1950	Fla. 449 x Cardinal	W987	B
1954	Fla. 449 x Lake Emerald	W1521	B

[z]Uses: B = breeding; JL = jelly; JU = juice; RS = rootstock; RW = red wine.

Table 4: Second generation of crosses and their PD-resistant progeny

Year of cross	Combination	Resistant progeny selected	Main uses^z
1949	W381 x Cardinal	W907	B
1961	W382 selfed	21C-31	B
1956	W987 x Lake Emerald	Norris	B
1957	W1001 x Villard Blanc	B3-83, B3-90	B
1956	Mantey x Roucaneuf	Stover	WW
1961	W716 x Buffalo	Liberty	B
1961	W716 x Sultanina	15B-23	B
1983	BD10-51 x Ruby Cabernet	AN5-75	RW
1958	W1521 x Villard Blanc	C5-50	B
1965	W1521 x Aurelia	E18-63	B
1976	W1521 x Aurelia	DC1-39, DC1-56	B

^{z}Uses: B = breeding; RW = red wine; WW = white wine.

Foundation parents selected from *V. aestivalis* ssp. *smalliana*, *V. aestivalis* ssp. *simpsoni*, and *V. shuttleworthii* contributed PD resistance and tolerance to stresses such as warm night temperatures, high humidity, torrential rainfall during ripening, and low fertility soils (Table 1).

The best sources of fruit size, high quality, and productivity were Aurelia (Villard blanc x Chaouch), Caroline Blackrose (Aurelia x Blackrose), Cardinal, Exotic, Golden Muscat and Villard blanc. Lakemont and Perlette were the best parents for seedlessness and early ripening. Tables 2 through 7 present 5 generations of the best crosses and their outstanding progeny selected during the 40 years. Pedigrees may be traced by proceeding backwards through the tables from a given outstanding cultivar selected.

Inbreeding reduced vine vigor and resulted in smaller leaves and shorter internodes, but was useful in developing parents more homozygous for disease resistance. Subsequent crossing of these inbreds to large-fruited, high-quality cultivars such as Fla. F5-8 and Cardinal resulted in progeny with restored vigor and improved recombinations such as Blanc Du Bois (Mortensen 1988). New cultivars arising from the program now form the basis for commercial grape growing in Florida (Halbrooks and Mortensen 1989).

At least one parent in the combinations should be resistant to PD and grow vigorously on its own roots. Crosses where both parents require grafting for good performance usually had progeny lacking in vigor in Florida sand land. In fact, many seedlings from such parentages failed to reach the trellis wire and fruit normally. Prevalence of parasitic nematodes in non-fumigated sandy soil is

Table 5: Third generation of crosses and their PD-resistant progeny

Year of cross	Combination	Resistant progeny selected	Main uses^z
1956	Fla. 449 x W907	A4-23	B
1961	Norris x Schuyler	D4-176	B
1963	Norris x Concord	E11-40	B
1963	Norris x Blue Lake	E9-48	B
1964	Norris x Alden	F8-35	B
1980	B3-83 x Blanc Du Bois	BD7-33	WW
1964	B3-90 x Exotic	Daytona	T
1983	Stover x NC74C039-1	RN2-21	WW
1964	C5-50 x Exotic	F5-8	T, B
1973	C5-50 x Liberty	BD6-47	B
1981	E18-63 x NY45791	CA11-17	T, B
1982	E18-63 x Lakemont	BN8-25	T
1982	DC1-39 x Himrod	BN6-85	T

^z Uses: B = breeding; T = table; WW = white wine.

thought to be a major factor inhibiting seedling growth of the progenies. Root-knot nematodes were prevalent among roots of older seedlings when removed for discard.

One outstanding breeding clone was Fla. W1521, which contributed vigor, high budbreak percentage and longevity; resistance to PD, anthracnose (*Elsinoe ampelina* DE BARY (SHEAR)), downy mildew (*Plasmopara viticola* (B. et C.) BERL. et DE T.) and fruit rots; and adaptability to frequent summer rainfall without fruit cracking or uneven ripening. Fla. W1521 was a parent of 4 outstanding clones in Table 4, a grandparent of 6 in Tables 5 and 6, and a great-grandparent of 5 clones in Tables 6 and 7. Another outstanding breeding clone was Norris, which contributed large size of berry and cluster along with resistance to Pd and downy mildew and susceptibility to anthracnose. Norris was parent to 4 elite clones in Table 5, grandparent to 4 in Table 6, and great-grandparent to 4 in Table 7. Both Fla. W1521 and Norris are pistillate-flowered, had Lake Emerald as their pollen parents, and had Fla. 449 as their mother and grandmother, respectively (Tables 3 and 4).

Lake Emerald (a *V. aestivalis* ssp. *simpsoni* derivative) contributed PD resistance, productivity, and vigorous growth under humid, subtropical environmental stresses. Fla. 449 (a *V. aestivalis* ssp. *smalliana*) contributed resistance to PD, downy mildew, powdery mildew

Table 6: Fourth generation of crosses and their PD-resistant progeny

Year of cross	Combination	Resistant progeny selected	Main uses[z]
1961	A4-23 selfed	D6-148	B
1964	A4-23 x Perlette	F9-68	B
1973	D4-176 x F9-68	Orlando Seedless	T, B
1983	BD5-67 x F9-68	DN15-12	RW
1969	E12-59 x E11-40	Conquistador	T, JU, JL
1972	E9-48 x Ark. 1105	BD12-49	WW, T
1968	C5-50 x F8-35	Suwannee	WW, B
1980	Daytona x Stover	BD5-117	T, B
1969	21C-31 x F5-8	L9-10	WW
1982	BD6-47 x Ark. 1105	BN5-101	T, B

[z]Uses: B = breeding; JL = jelly; JU = juice; RW = red wine; T = table; WW = white wine.

Table 7: Fifth generation of crosses and their PD-resistant progeny

Year of cross	Combination	Resistant progeny selected	Main uses[z]
1968	D6-148 x Cardinal	Blanc Du Bois	WW
1983	BD7-75 x Orlando Seedless	DN21-83	B
1978	W716 x Suwannee	CA4-66, CA4-72	RW
1982	Suwannee x Verdelet	CN1-90	WW, B

[z]Uses: B = breeding; RW = red wine; WW = white wine.

(*Uncinula necator* (SCHW.) BURR.), anthracnose, black rot (*Guignardia bidwellii* (ELL.) VIALA et RAVAZ), and grape leaf folder moth (*Desmia funeralis* HÜBNER).

With careful parental selection and fruiting of progeny with population sizes of > 100 seedlings per cross it has been possible to obtain new recombinants of superior value as cultivars.

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Effects of European red mite on grapevine cultivars

G. RILLING and H. DÜRING

Bundesforschungsanstalt für Rebenzüchtung Geilweilerhof, D-6741 Siebeldingen, F. R. Germany

A b s t r a c t : Responses of *Vitis* cvs to attack by *Panonychus ulmi* may vary depending on grapevine genotype. Investigations were carried out: (i) to elaborate a screening system which can be used as a tool in breeding grapevines tolerant to spider mite infestation; (ii) to analyse damage of grapevine leaves caused by red spider mite.

A 9-point visual screening system based on the extent of leaf bronzing due to the mites' feeding activity was established. There was no strict correlation of leaf discoloration with population density of spider mites. Discoloration was, however, positively connected with the frequency of feeding necroses (the histology of which was also studied). Negative correlations were observed with chlorophyll contents of leaves, photosynthesis rate, stomatal conductance and transpiration rate.

The significant relationships between bronzing and objective parameters confirm the validity of the visual screening system as a quick method for estimating the degree of damage due to *P. ulmi* on grapevine breedings.