

Using *Vitis* species to improve cultivated grapes

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How many grape species are there?

- ~60 *Euvitis* aka *Vitis* (bunch grapes)
 - $2n=2x=38$
 - 30 in North America and 30 in Asia
- 1* *Muscadinia* aka *Vitis rotundifolia*
 - $2n=2x=40$
 - *Run1* powdery mildew resistance introgressed into breeding programs

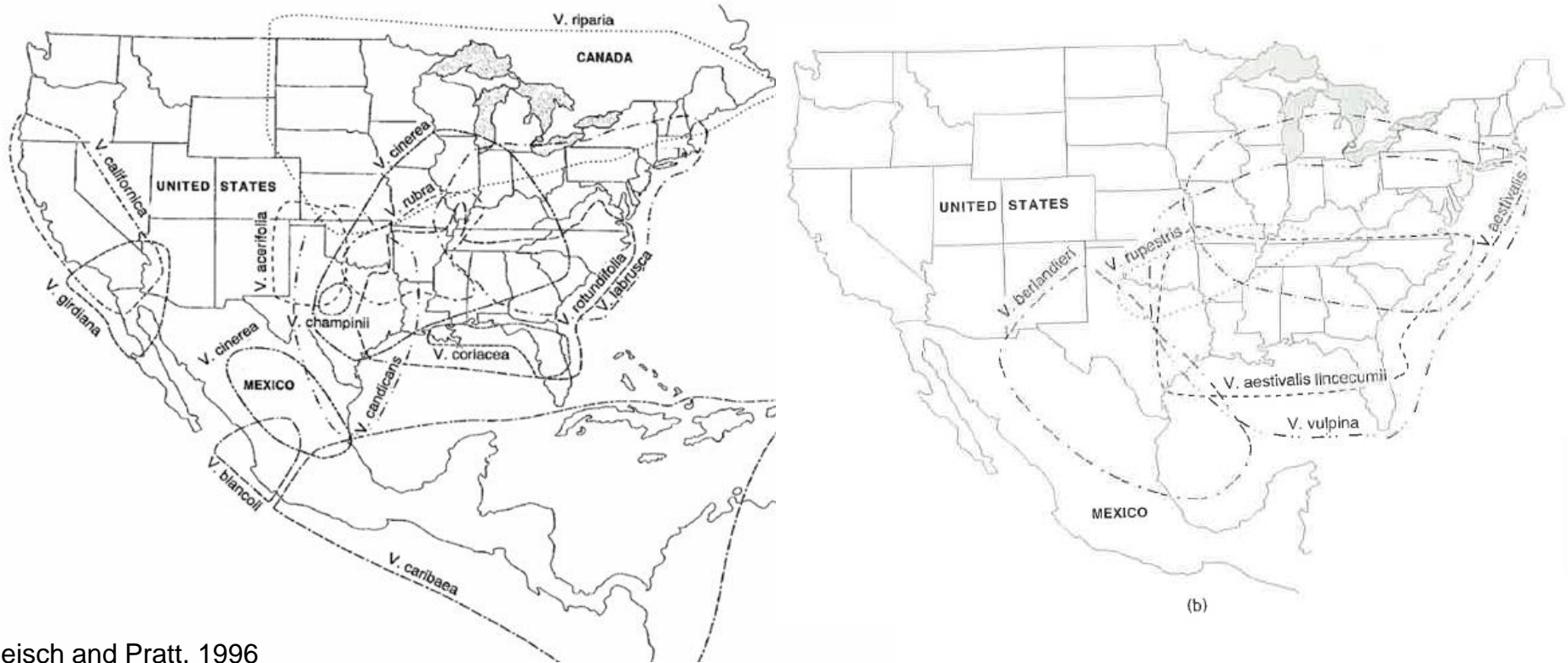


From A. Millardet's *Histoire des Epèces de Vignes d'Origine Americaine qui resistant au Phylloxera*, (1885) [History of Phylloxera-resistant Vine Species of American Origin].
<http://www.vinetowinecircle.com/en/history/the-american-plagues/>

* Some suggest 3 species



Distribution of *Vitis* in North America



Reisch and Pratt, 1996



More *Vitis* trivia

- Grapes are dioecious (male and female plants)
- Grapes interbreed “easily”
- Grapes are important to humans
 - Fresh eating, juice, wine
- 1 Million acres of plantings in US
- 6th Largest Fruit crop
- Highest value fruit crop



Early Hybridizations

- America
 - Vinifera not suitable in Eastern US
 - Labrusca (Labruscana) hybrids (1800-1850)
 - Concord, Catawba, Isabella
- Europe
 - Seeing resistance to powdery mildew, downy mildew, and black rot
 - Inadvertently introduced phylloxera to Europe



Early hybridizations

- French-American Hybrids (aka direct producers)
 - Combined resistances from American species with *Vinifera*
 - Contributed to wine production (over 30%)
 - Effectively outlawed from production in Europe since 1930s
 - Economic downturn
 - Over production in European states and under consumption
 - Quality aspects like “foxy” flavor from N. American species



Who is breeding new grapes?

- Public Sector
 - U. Minnesota
 - Cornell University
 - USDA-ARS
 - Missouri State
 - U. California-Davis
 - U. Arkansas
 - U. Florida
- Private Companies
 - IFG
 - Sun World
- Numerous private breeders and hobbyists



Grape genetic resources

- Repositories
 - National Center for Genome Resources (Davis, CA)
 - Grape Genetic Research Unit (Geneva, NY)
- National Clean Plant Network
 - Foundation Plant Services
 - Clean Plant Center NW (Prosser, WA)



Domestication traits of grape

- High sugar content
- Large berries
- Perfect flowers
- Range of berry color
- Low acid?
- Seedless



Current breeding objectives: pest resistance

- Fungal pests
 - Powdery mildew (*Uncinula necator*)
 - Downy mildew (*Plasmopara viticola*)
 - Anthracnose (*Elsinoë ampelina*)
 - Black rot (*Guignardia bidwellii*)
 - Botrytis
- Bacteria: Pierce's Disease (*Xylella fastidiosa*)
- Insect pests: Phylloxera (*Daktulosphaira vitifoliae*)
- Nematodes and Virus



Abiotic Tolerance

- Cold hardy
 - *V. riparia*; *V. labrusca*, *V. aestivalis*
- Drought tolerance
- Iron chlorosis
- Salinity stress

- Propagation?
 - some species do not root well or have low graft compatibility



Introgressed Traits

Table 7.3 Sources of resistance to insect pests

Insect	Species	References
Root knot nematodes	<i>V. × champinii</i> , <i>V. mustangensis</i> , <i>V. rotundifolia</i> , <i>V. nesbittiana</i> , <i>V. × slavini</i> , <i>V. aestivalis</i> var. <i>aestivalis</i> , <i>V. vulpina</i>	Lider 1954, Firoozabady and Olmo 1982, 1986, Bloodworth et al. 1980, Cousins and Walker 2002, Boyden 2005, Anwar et al. 2002
Dagger nematodes	<i>V. aestivalis</i> var. <i>aestivalis</i> , <i>V. cinerea</i> , <i>V. rotundifolia</i>	Alleweldt et al. 1990, Meredith et al. 1982, Becker and Sopp 1990
Phylloxera	<i>V. riparia</i> , <i>V. rupestris</i> , <i>V. cinerea</i> var. <i>helleri</i> , <i>V. cinerea</i> , <i>V. × champinii</i> , <i>V. rotundifolia</i>	Alleweldt et al. 1990, Olmo 1986

Table 7.4 Sources of adaptation to abiotic stress

Stress	Species	References
Cold Damage	<i>V. riparia</i> , <i>V. labrusca</i> , <i>V. amurensis</i> , <i>V. acerifolia</i> , <i>V. vulpina</i> , <i>V. adstricta</i>	Alleweldt et al. 1990, He and Lixin 1989, Luby 1991
Drought stress	<i>V. vinifera</i> , <i>V. rupestris</i> , <i>V. champinii</i> , <i>V. cinerea</i> var. <i>helleri</i>	Alleweldt et al. 1990, During 1986
Iron chlorosis	<i>V. vinifera</i> , <i>V. cinerea</i> var. <i>helleri</i>	Alleweldt et al. 1990, Pouget 1980
Salinity	<i>V. cinerea</i> var. <i>helleri</i> , <i>V. × champinii</i> , <i>V. acerifolia</i>	Alleweldt et al. 1990, Antcliff et al. 1983, Galet 1988

Table 7.2 Sources of disease resistance in grapes

Disease	Species	References
<i>Fungal</i>		
Powdery Mildew	<i>V. riparia</i> , <i>V. aestivalis</i> , <i>V. cinerea</i> , <i>V. cinerea</i> var. <i>helleri</i> , <i>V. rotundifolia</i>	Alleweldt et al. 1990 Pearson et al. 1988
Downy Mildew	<i>V. riparia</i> , <i>V. rupestris</i> , <i>V. aestivalis</i> var. <i>lincecumii</i> , <i>V. labrusca</i> , <i>V. amurensis</i> , <i>V. rotundifolia</i> , <i>V. yenshanensis</i> , <i>V. pseudoreticulata</i> , <i>V. piasezkii</i> , <i>V. romanetii</i> , <i>V. flexuosa</i> , <i>V. bryoniifolia</i>	Alleweldt et al. 1990 Eibach et al. 1989 He and Wang 1986
Black rot	<i>V. riparia</i> , <i>V. mustangensis</i> , <i>V. rotundifolia</i> , <i>V. cinerea</i> , <i>V. rupestris</i>	Alleweldt et al. 1990 Jabco et al. 1985 McGrew 1976
Anthracnose	<i>V. cinerea</i> var. <i>floridana</i> , <i>V. aestivalis</i> var. <i>aestivalis</i> , <i>V. shuttleworthii</i> , <i>V. labrusca</i> , <i>V. rotundifolia</i> , <i>V. rotundifolia</i> var. <i>munsoniana</i>	Mortenson 1981 Olmo 1986
Botrytis bunch rot	<i>V. vinifera</i> , <i>V. riparia</i> , <i>V. rupestris</i>	Alleweldt et al. 1990
Rust	<i>V. shuttleworthii</i> , <i>V. cinerea</i> var. <i>floridana</i> , <i>V. rotundifolia</i> , <i>V. tiliifolia</i>	Fennell 1948
Rotbrenner	<i>V. vinifera</i> , <i>V. cinerea</i>	Alleweldt et al. 1990
<i>Bacterial</i>		
Pierce's disease	<i>V. rotundifolia</i> , <i>V. mustangensis</i> , <i>V. × champinii</i> , <i>V. vulpina</i> , <i>V. shuttleworthii</i> , <i>V. cinerea</i> var. <i>floridana</i> , <i>V. aestivalis</i> var. <i>aestivalis</i> , <i>V. arizonica</i>	Mortenson 1977 Olmo 1986 Stover 1960 Krivanek et al. 2005
Crown gall	<i>V. amurensis</i> , <i>V. labrusca</i>	Alleweldt et al. 1990 Szedgi et al. 1984 Pearson et al. 1988
Flavescence doree	<i>V. labrusca</i> , <i>V. rupestris</i>	Pearson et al. 1988
<i>Virus</i>		
Grapevine fanleaf virus	<i>V. rotundifolia</i> , <i>V. vinifera</i> , <i>V. arizonica</i> , <i>V. aestivalis</i> var. <i>aestivalis</i> , <i>V. × slavini</i> , <i>V. mustangensis</i> , <i>V. riparia</i>	Walker et al. 1985 Walker and Meredith 1990 Bouquet 1981



Minnesota Specific Issues

- Heavy and rich organic matter soils
- Extreme cold winter temperatures
- Short growing season
- High humidity and wet growing season
- No need to graft !! 😊

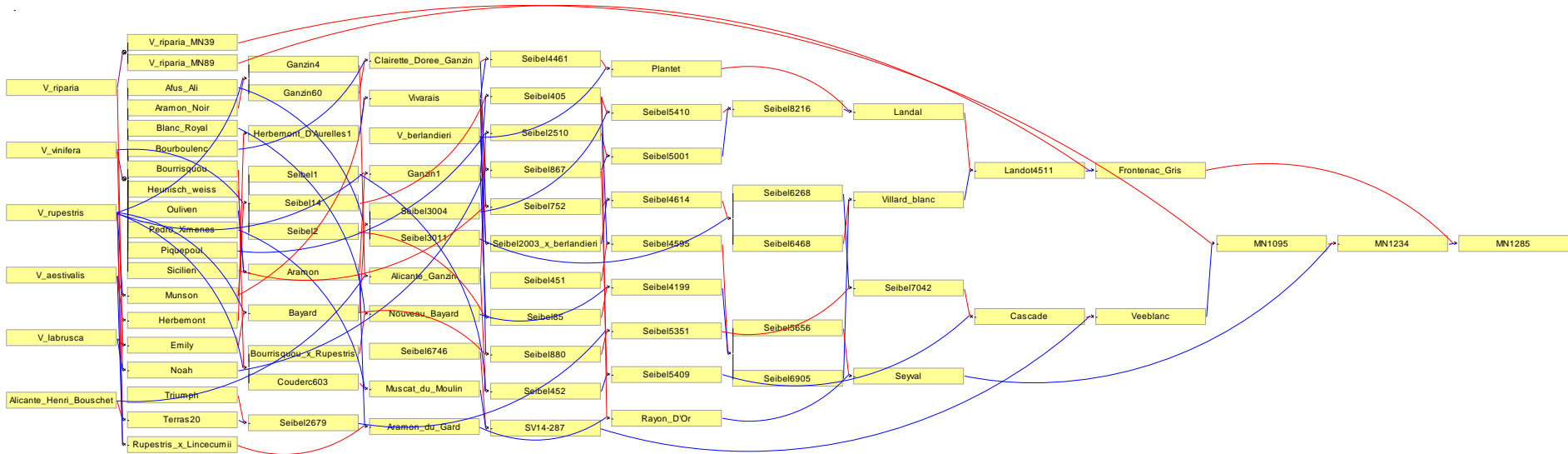


Constraints

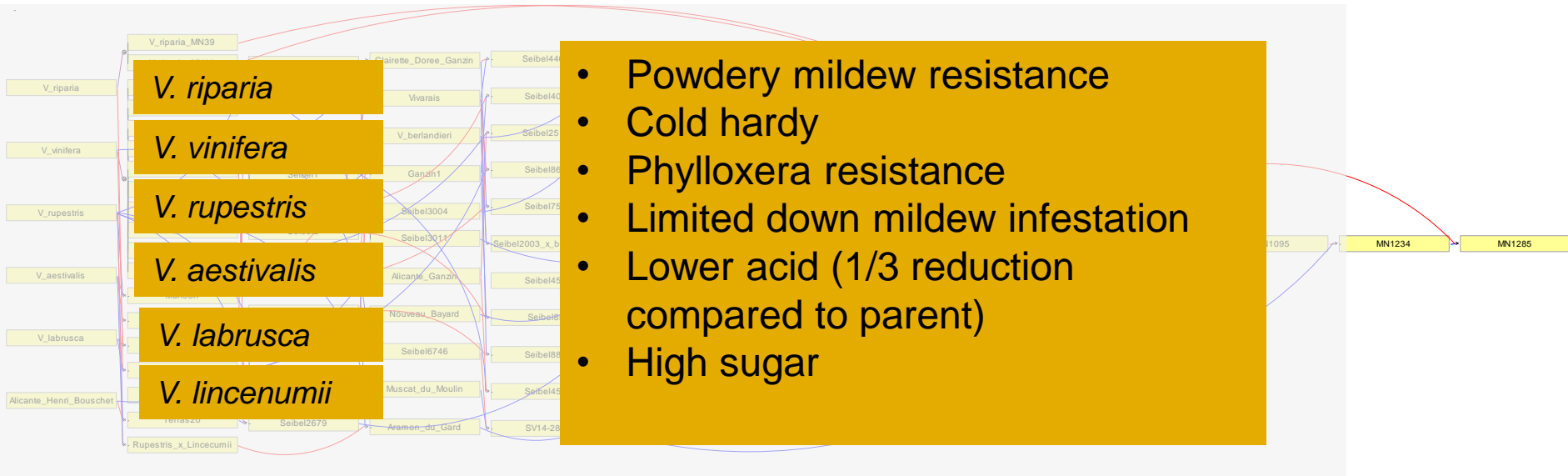
- Crossing Good x “Bad” (except for a single trait)
 - Linkage drag
- Inbreeding depression
- Long generation time (20 year for cultivar release)
- Wild populations serve as reservoirs for pests and disease
- Reduced habitat for some species
- Hybrid acceptance can be low



Pedigree data for 'Itasca'

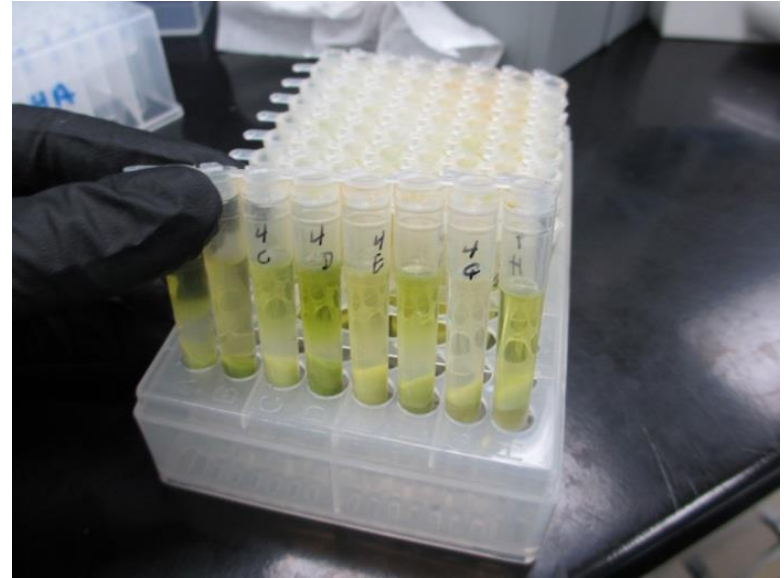


Pedigree Data for Grape Breeders



Marker-informed breeding for efficiency

- Map traits of interest (examples)
 - Powdery mildew
 - Color (anthocyanins)
 - Cluster compactness
 - Phylloxera resistance
- Develop DNA tests
- Use pedigree data
- Screen parents
- Screen seedlings



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