California Department of Food and Agriculture PD/GWSS
Progress Report – July 2016

REPORT TITLE: Interim Progress Report for CDFA Agreement Number 15-0425-SA

PROJECT TITLE: Breeding Pierce's disease resistant winegrapes.

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INTRODUCTION

We continue to make rapid progress breeding Pierce's disease resistant winegrapes. Our main focus to date has been on the Pierce's Disease resistance locus, *PdR1*, from the b43-17 *V. arizonica/candicans* resistance source. There are two forms of *PdR1*, 8909-08 and 8909-17 – sibling progeny of b43-17 and they have different alleles of *PdR1* denoted *PdR1b* and *PdR1a*, respectively. Marker-assisted selection (MAS) is used to select candidate resistant progeny as soon as seeds germinate which combined with aggressive vine training and selection for precocious flowering has allowed us to reduce the seed-to-seed cycle to two years. PD resistance is confirmed in the greenhouse using rapid screening techniques for *Xylella fastidiosa* (*Xf*) resistance developed in the Walker Lab (Buzkan et al. 2003, Buzkan et al. 2005, Krivanek et al. 2005a 2005b, Krivanek and Walker 2005). Advanced selections with the highest levels of resistance have had wines made for multiple years. Over the past 6 years we have made wine from vines that are at the 94% *to 97% vinifera* level from this same *PdR1* resistance background. Thus far, 16 scion selections and 3 PD resistant rootstocks have been advanced to Foundation Plant Services (FPS) to begin the certification and release process. Other forms of *V. arizonica* and other southwestern US (SWUS) species are being studied (see companion report) and the resistance of some will be genetically mapped for future efforts to combine multiple resistance sources and ensure durable resistance. Stacking of *PdR1b* with b42-26 (*V. arizonica-girdiana*) PD resistance began in 2011 and last year was advanced to the 92% *V. vinifera* level using MAS to confirm the presence of *PdR1b* and greenhouse screening to verify higher than usual levels of Pierce's disease resistance. Resistance from southeastern United States (SEUS) species is being advanced more slowly since resistance in these latter lines is complex and markers have not yet been developed to expedite breeding.

OBJECTIVES

1. Identify additional unique sources of *Xf* resistance; develop breeding populations and phenotype them with our greenhouse screen to characterize their inheritance of resistance.
2. Develop ~97% *vinifera*-based PD resistant lines of winegrapes utilizing diverse sources of resistance to *Xf*, and conduct fruit and wine evaluations.
3. Utilize marker-assisted selection to allow stacking of resistance loci, screen for resistant genotypes, and develop backcross generations by crossing resistant selections to elite *vinifera* varieties in order to produce high quality and PD resistant winegrapes.
4. Develop and maintain new and existing genetic mapping populations to assist companion mapping/genetics project; begin the mapping of fruit quality traits such as color, tannin content, flavor, and productivity in PD resistant backgrounds.

RESULTS AND DISCUSSION

Having nearly completed our evaluations of all the various 97% *vinifera PdR1b* cross progeny from crosses made in the 2009-11 period and with six of the best *PdR1b*-based selections soon to be available to the industry, we have turned our breeding focus to stacking *PdR1*-based PD resistance with the quantitatively resistant b42-26 line to create PD resistant scion varieties capable of resisting more aggressive mutant forms of *X. fastidiosa*. In addition to the PD resistance resources discussed above, the Walker Lab also has diverse sources of powdery mildew (PM) resistance and incorporating powdery mildew resistance into novel PD resistant varieties would add substantial value. Since PM is a universal scourge to *vinifera* grape culture, the identification of resistance loci with published genetic markers has been the goal of breeders around the world and many forms of resistance (some with good markers) are available. To enhance functionality of our advanced PDR lines we continue to stack them with these various PM resistance loci. Table 1 details our MAS testing results and planting details for the PD resistance crosses made in 2015. In Table 1a powdery mildew resistance from a *V. vinifera* and *V. romanetii* source (*Ren1* and *Ren4*) were combined with PD resistance from *PdR1b* and b42-26 in a 4-way stack at the 95% *vinifera* level. Similarly in Table 1b a 3-way PDR-PMR stack was created using the *Ren4* PM resistance locus and our two most advanced PD sources. Table 1c lists the 3-way stacks of *PdR1b* PD resistance with the *Ren1* and *Ren4* PM resistance sources we created while in Table 1d we use *Run1* (a *M. rotundifolia* resistance source) instead of *Ren1* in a similar 3-way stack. In Tables 1a-d the PD resistant parents are homozygeous at *PdR1b* so all progeny should carry this PD resistance. Our most promising mapping and breeding crosses to novel new PD resistant sources are being tested for trueness to type (Table 1e).

Table 1. 2015 PD Crosses MAS Tested and planted in the field.

Cross PDR Type	Cross PM Type	% Vinifera	# MAS tested	# to field
1a. *PdR1b^2 x* b42-26	*Ren1,Ren4*	95%	340	86
1b. *PdR1b^2 x* b42-26	*Ren4*	95%	25	9
1c. *PdR1b^2*	*Ren1,Ren4*	96%	155	80
1d. *PdR1b^2*	*Run1,Ren4*	93%	120	41
1e. *PdR1b*^2, b46-43 F1 map	None	93%,75%	380	242

Our 2016 crosses (Table 2) we expand on our 2015 efforts with increased numbers and focus on parents with superior horticultural and fruit quality traits. Crosses made in Table 2a represent backcrosses to elite *vinifera* wine varieties to various parents from a 3 x 3 crossing of the *PdR1b* x b42-26 lines at the 92% *vinifera* level. Resistant parents were selected based on GH results summarized in Table 5. Table 2b presents intercrosses among the most resistant progeny from the 3 x 3 crossing to further explore compatibility and resistance in this stacking. Table 2c shows a first crossing of elite *PdR1b* types to a 3-stack powdery mildew resistant line to confirm lack of segregation distortion between this combination of resistance loci. Table 2d presents similar crosses although at a lower percent *vinifera* level. These crosses were created to check the functionality of a 2 PD x 3 PM resistance stack. To increase the percentage of progeny with *PdR1b*, we cross either to a parent homozygeous at *PdR1b* or have both parents carry *PdR1b* (Tables 2e,f,g). Similarly we accomplish the same increase in percentage progeny with PM resistance markers however again at a slightly lower *vinifera* level as shown in Tables 2f and 2g.

Table 2. PD crosses made in 2016 with percent *vinifera*, most recent elite *vinifera* parent and estimated number of seeds produced.

Cross PDR Type	Cross PM Type	% *vinifera*	*vinifera* Parents/Grandparents or …/most recent *vinifera* parents	# Crosses	Est. # Seeds
*2a. PdR1b*xb42-26	none	96%	Chardonnay, Cabernet Sauvignon, F2-35, Primitivo/Chardonnay, Zinfandel	9	875
*2b. PdR1b*xb42-26	none	92%	Zinfandel, Chardonnay	17	2,240
2c. PdR1b	*Ren1,Ren4,Run1*	96%	Zinfandel/F2-35	2	75
*2d. PdR1b*xb42-26	*Ren1,Ren4,Run1*	92%	.../Grenache, Zinfandel	5	240
*2e. PdR1b^2*xb42-26	*Ren1,Ren4*	94%	.../F2-35, Grenache, Zinfandel	3	185
*2f. PdR1b^2*xb42-26	*(Ren1,Ren4)^2*	90%	.../F2-35, Karadzhandal, Zinfandel	1	500
*2g. (PdR1b*xb42-26)^2	*(Ren1,Ren4)^2*	90%	.../F2-35, Grenache, Zinfandel	4	925

We have reported previously the surprising result from our companion PD mapping project that most of the resistance lines we have explored from the southwestern US have PD resistance associated with linkage group (LG) 14, the same locus region as our main resistance line *PdR1b*. In Table 3 we detail crosses made in 2016 to advance lines that preliminary screening indicated are not located on LG14. Crosses in Table 3a created progeny to expand existing F1 mapping populations from the ANU67, b41-13 and T03-16 sources (all accessions from southwestern *Vitis* species). Some of the progeny from these F1 lines exhibited significant resistance, but few highly resistant progeny were detected in the T03-16 line. Crosses in Table 3b were made to examine whether complete PD resistance in this line could be recovered through full sib crossing in the F1 generation. Two elite F1 individuals from the b41-13 line and the three most resistant F1 genotypes in the T03-16 line were backcrossed to the indicated elite *vinifera* parents (Table 3c) to create new breeding lines at the BC1 level. These will ultimately be combined with the b42-26 line to enhance and broaden PD resistance in our main *PdR1b* resistance crosses.

Table 3. 2016 Crosses made to expand new PD mapping populations and advance breeding lines to the next backcross level.

Group	Cross PDR Source	% *vinifera*	*vinifera* Parents/ Grandparents	# Crosses	Est. # Seeds
3a	ANU67	50%	F2-35	1	300
	b41-13	50%	F2-35	1	700
	T03-16	50%	Palomino	1	55
3b	T03-16	50%	Palomino	3	150
3c	b41-13	75%	Rosa Minna, Primitivo/F2-35	2	305
	T03-16	75%	F2-35/Palomino	3	150

Table 4 provides a list of the PD greenhouse screens analyzed, initiated and/or completed over the reporting period. Group 4A is an extensive test of 245 progeny from a 3 x 3 cross at the 92% *vinifera* level involving *PdR1b* x b42-26 with results reported in Table 5 below. This group also included testing of 9 PD resistant rootstocks. Three previously identified selections from 2011 crosses were confirmed as highly resistant and have been moved to multi-vine trials in Davis. We also found that five *V. tiliifolia* seedling selections from the Caribbean all proved moderately to highly susceptible to PD so we have abandoned this resistance source.

One hundred and twenty more progeny from the b42-26 background were tested in Group 4B in an effort to improve the genetic map in this multigenic resistance background. In an attempt to identify missing resistance factors in the BC1 07-344a b42-26 line, we also tested 25 genotypes in an alternate BC1 population derived from a different highly resistant F1 parent. We also tested 20 genotypes which have *PdR1b* and the *Ren1* and *Ren4* PM resistance loci. ELISA results are pending.

ELISA results for Group 4C are pending so the comments that follow are based on our CMI PD disease phenotype scores. We tested 42 BC1 progeny in the ANU5 line for the presence of minor resistance genes as we now believe it to have its major source of PD resistance on LG14. Five genotypes exhibited intermediate resistance so could be of some interest. We also tested 35 genotypes at the BC2 or BC3 level in the b40-14 breeding line, the source of our *PdR1c* resistance source. Twenty-two genotypes were rated as either highly resistant or promising and will be used to advance this resistance source to the 97% *vinifera* level. In the retest of 45 genotypes previously identified as promising, a total of 28 selections from various sources including A14, A28, b40-29, b46-43, BD5-117xHC, *PdR1a*, *PdR1b*, and SAZ7 were scored as highly resistant.

We continue to refine our rapid GH screen with an experiment in Group 4D. We have observed that expression of PD symptoms increases when the test plants in a given trial become water stressed. In addition, in at least one trial, symptoms were dramatically diminished when excess irrigation levels were maintained. Plant water status also appears to impact bacterial titer. In this experiment we will better define the water status impact on PD expression using our 4 *PdR1* and 2 SEUS biocontrol genotypes that range in symptom levels and *X. fastidiosa* titers. In our companion PD mapping project we identified a major PD resistance locus on LG14 in the b46-43 line. Group 4E tests approximately 100 genotypes to check for any supporting resistance loci.

Table 4. Greenhouse PD screens analyzed, completed and/or initiated during the reporting period.

Group	Test Groups	No. of Genotypes	Inoculation Date	ELISA Sample Date	PD Resistance Source(s)
4A	92% PdR1bxb42-26 Stack, Parents & BCs, PD Rootstock	275	10/27/2015	1/26/2016	PdR1b,b42-26
4B	Addn b42-26 F1, Alt b42-26 BC1	171	3/1/2016	5/31/2016	PdR1b,b42-26
4C	ANU5, b40-14, Promising selections from 2015 GH Screens, PD x PM	152	4/14/2016	7/14/2016	ANU5,b40-14, *PdR1b*,b42-26
4D	BC-UBC Irrigation Level Trial	7	4/14/2016	7/14/2016	PdR1b & SEUS biocontrols
4E	14-399 b46-43 BC1 Mapping MPP	117	5/4/2016	*8/3/2016*	b46-43

Table 5a presents the number of progeny tested in each pairing of a 3 x 3 crossing of the *PdR1b* x b42-26 lines at the 92% *vinifera* level in a recently completed greenhouse screen (Group 4A above). Table 5b presents the population mean ELISA results that quantify the level of PD causing bacteria of the genotypes in each population. Most importantly, Table 5c shows the ratio of progeny where all reps are statistically more resistant than our standard *PdR1b* biocontrol genotype to the number of genotypes tested. The next step in our stacking, completed this Spring (Table 2b above), was the intercrossing of numerous of the most resistant individuals descending from different parent combinations identified from this group to create breeding genotypes homozygeous at *PdR1b*, enriched in b42-26 QTLs, and showing no *Xf* titer by ELISA and no CMI symptoms. A final step would then be to cross the most promising and resistant of these elite *vinifera* varieties to create populations that are 96% *vinifera* in which all progeny have *PdR1b* and all should be highly PD resistant. The most promising selections would then be advanced to FPS for certification and release as the next iteration of our PD resistant scion breeding efforts. In Table 2a above we also made crosses of the most resistant progeny directly to elite *vinifera* as baseline populations to quantify the value of double stacking the b42-26 resistance.

Table 5. PD natural log of cfu/ml detected by ELISA on progeny from nine *PdR1b* x b42-26-line crosses 13 weeks after *X. fastidiosa* inoculation in our greenhouse screen: # tested, progeny means, and ratio # rated completely resistant (score = 10) or highly resistant (score = 5) to # tested. "n – xx" denotes the 10-301 b42-26 pollen parent most recently descended from Chardonnay and the 09331-xxx identifies the *PdR1b* seed parent most recently related to Zinfandel.

PdR1b x b42-26	5a. Progeny # Tested			5b. Progeny mean cfu/ml			5c. Ratio # scored 5 or 10 / # tested		
Parents mean ln cfu/ml				11.4	11.3	11.1			
Parents	n-14	n-20	n-47	n-14	n-20	n-47	n-14	n-20	n-47
10.9, 09331-033	53	34	14	10.3abc	10.4abc	10.0a	0.21	0.18	0.43
9.7, 09331-122	27	38	17	10.4abc	10.4bc	10.8de	0.04	0.11	0.00
9.8, 09331-153	20	21	21	10.7cd	11.1e	10.9de	0.10	0.05	0.05

On May 6, 2016 a tasting was held at UC Davis to evaluate 2015 vintage wines from our new PD resistant varieties. A total of 17 tasters comprised of winemakers, viticulturists, faculty, staff and students rated the wines on a hedonic quality scale from 1 = poor to 5 = very good. All wines were produced from grapes grown in Davis. Results are summarized in Table 6. It can be seen from the range of quality scores for each of the wines that the tasters didn't assess the wines uniformly. However no taster rated every wine as poor and most wines were considered "very good" or nearly so by at least one taster. Analysis by ANOVA for parameters color, taster and combination of the two found no preference for color and no interaction. Overall some tasters rated the wines higher than others. In one way analysis within color, for the whites there was no separation of variety and for the reds only 07355-075 was significantly preferred to Lenoir. With a mean score of 3.1 and a root mean square error of 0.86 for all UCD PD wines considered together, they were perceived as being of average quality. This is significant praise from a group of professionals familiar with evaluating some of the finest *vinifera* wines in the world especially considering that the wines were produced from grapes grown in Davis, were less than a year months old and had no oak treatment.

Table 6. Results of a tasting of 2015 vintage wines tasted 5/6/16 at UC Davis.

Wine Name	% vinifera	Color	Average Score	Max Score	Min Score	5/6/16 Consensus Descriptors: color; aroma; flavor-texture
07370-084	94%	W	3.2	5	2	Pale yellow, clear; pear, melon, tropical with slight citrus; fruity, stone fruit, balanced, good acidity.
09338-016	97%	W	3.5	5	2.5	Light straw-gold, clear; apple-melon, lychee, floral; ripe, pineapple, green apple, juicy, harmonious, round.
09314-102	97%	W	2.9	4.5	2	Light straw, clear; citrus, tropical, gooseberry; bright fruit, lime, golden delicious apple, slightly bitter, textured.
Chardonnay	100%	W	3.2	4.5	2	Pale yellow, clear; fruity, apple, mint, spice, slightly sweaty; spicy green fruit, fat, soft, short, slightly astringent.
Blanc du Bois	66%	W	3.4	5	1	Med straw-gold, clear; melon, peach, muscat; tropical, rose, moderate intensity, balanced, long.
09331-103	97%	R	2.8	4.5	2	Dark red purple; blackberry, cherry, spice, vinous, cedar, slightly herbal; black pepper, spice, ripe berry, soft, nice length.
Cabernet Sauvignon	97%	R	3.2	5	2	Dark- red purple; jammy, stemmy, herbal, coffee, candied; grapy, fruity, jammy, leafy, tannic, slightly bitter.
07355-075	94%	R	3.4	4	1.5	Dark- red purple; bright red fruit, raspberry, cherry, compote; ripe, tannic, elegant rather than dense.
Lenoir	50%	R	2.8	4	1	Dark red-brown; herbal, dried floral, odd medicinal, oxidized; weedy, stemmy, unusual, lacking in tannin.
09356-235	97%	R	3.1	5	1	Dark- red purple; complex fruit with herbs and earth, plum, jammy; big wine, dense, rich middle, tannic yet balanced.
09331-047	97%	R	3.2	5	1	Med-dark red purple; berry pie, cassis, herbal, dried hay, mature; coffee, vegetal, licorice, round, soft.
09330-07	97%	R	2.9	5	1.5	Dark purple with some red; berry, current, fruity, slight candy; ripe, round, relatively soft tannins, full and long.

To determine the field resistance of our various PD varieties, over the last 15 years we and cooperators have established field trials in various PD hotspots around California and in several southern States where PD is endemic (Table 7). At the Yountville / Beringer site we have inoculated with *X. fastidiosa* for 7 years and have also mechanically inoculated vines at the Drake/Temecula Vineyard in 2015. At the other locations we rely on natural infection. To date all our resistant vines in these diverse settings continue to thrive. In 2013, we began noticing Red Blotch virus spreading rapidly through our existing trial and within a year it had spread through the first 100-vine plantings of our advanced PD resistant vines planted earlier that year. We continue to monitor the PD status of the vines, but are no longer able to make wines for this site due to the virus infection.

Caymus Winery and Paul Skinner generously offered to plant two of our advanced selections along the Napa River on Mee Lane, St. Helena (Figure 1). They planted rootstock and chip-budded 07355-075 and 09311-047 and now have 375 and 1,125 vines that will be harvested this year. They are also willing to plant 1,000 more and we are meeting soon to decide which selections. This trial will give us an excellent view of the commercial potential of these selections and it is planted in a severe riparian PD hot spot. Figure 1 presents the plot as it looked last summer.

I will be going to Driftwood, Texas in November to check on our research plots and present the PD breeding program with a talk and tasting. We have been collaborating with Jim Kamas (Texas A&M, Fredericksburg) who has planted 7 of our 88% *vinifera* and 4 of our 94% selection in sites across a range of severe PD region (Fredericksburg, Leakey, Hye and Industry TX). Resistance is holding up well in all the selections, although some are more susceptible to the high limestone soils and downy mildew. We also sent 88 and 94% selections to Gainesville FL for testing with the University of Florida. Mercy Olmstead is directing this trial although she is leaving soon. The vines are establishing well and showing no signs of disease.

Table 7. Numbers of grafted UCD PD resistant vines by selection in various field trials. 05 selections are 88% *vinifera*, 07 are 94% and 09 are 97% *vinifera*. The green shaded vines are being considered for release.

Genotype	Ben Drake Vineyard, Temecula, CA (2014)	Beringer, Napa Valley, CA (2001-13)	Caymus - Paul Skinner (2014-15)	Mounts, Sonoma County, CA (2012,2015)	Silverado Vineyards, Napa, CA (2014)	Texas (2008)	Alabama Auburn U /White Oak&Berra Vineyards (2011)	U Florida (2016)
U0501-12						86	30/wo	
U0502-01		6				86	30/	
U0502-07						86		
U0502-10		6				86	30/wo	
U0502-20				25			30/wo	40
U0502-26						100		
U0502-38						100	30/wo	
07329-37		9		25		100		
07355-075		105	375	25		100		40
07713-51		9		30		100		
07355-044								40
07338-37						100		40
07370-078								40
07370-084						100		40
09314-102	25			75	25			
09330-07	25				25			
09331-047	25		1125		25			
09331-133	25				25			
09333-178	25				25			
09333-253	25				25			
09333-331	25				25			
09333-370	25				25			
09338-016								

CONCLUSIONS AND LAYPERSON SUMMARY

We continue to make strong progress breeding Pierce's disease (PD) resistant winegrapes. Aggressive vine training and selection for precocious flowering have allowed us to reduce the seed-to-seed cycle to 2 years. We are also using marker-assisted selection (MAS) for the PD resistance gene, *PdR1* (see reports from our companion project) to select resistant progeny as soon as seeds germinate. These two practices have greatly accelerated the breeding program and allowed us to produce four backcross generations with elite *V. vinifera* wine grape cultivars in 12 years. We have screened through about 1,000 progeny from the 2009 and 2010 crosses that are 97% *vinifera* with the *PdR1b* resistance gene from *V. arizonica* b43-17. Seedlings from these crosses continue to fruit and those with high quality fruit are advanced to greenhouse testing, where only those with the highest resistance to *X. fastidiosa*, after multiple greenhouse tests, are advanced to multi-vine wine testing at Davis and at PD hot spots in California. We have now sent 16 scion and 3 rootstock advanced selections to FPS over the last three seasons to be certified and begin the release process with another 3 scion selections being sent this year. The first 6 advanced *PdR1b* varieties have been identified for release to the industry. Stacking of *PdR1b* resistance with resistance from the b42-26 *V. arizonica-girdiana* multigenic PD resistance source is advancing and promises enhanced levels of PD resistance and durability. PD resistance from *V. shuttleworthii* and BD5-117 are also being pursued, but progress is limited by the multigenic nature of their resistance. Other forms of *V. arizonica* are being studied and the resistance of some will be genetically mapped for additional efforts to combine/stack multiple resistance sources and ensure durable resistance. Very small-scale wines from 94% and 97% *vinifera PdR1b* selections have been very good, and have been received well at tastings in the campus winery and at public tastings in Davis, Sacramento, Healdsburg, Napa, Fresno and Temecula and Santa Rosa (Sonoma Winegrape Commission).

PUBLICATIONS RELATED TO WINEGRAPE BREEDING

Xie, X., C.B. Agüero, Y. Wang and M.A. Walker. 2015. *In vitro* induction of tetraploids in *Vitis* X *Muscadinia* hybrids. Plant Cell, Tissue & Organ Culture DOI 10.1007/s11240-016-1023-4.

Peressotti, E., C. Dolzani, L. Poles, E. Banchi, M. Stefanini, F. Salamini, R. Velasco, S. Vezzulli, S. Riaz, M.A. Walker, B.I. Reisch, W.E. Van de Weg, M.C.A.M. Bink. 2015. A first pedigree-based analysis (PBA) approach for the dissection of disease resistance traits in grapevine hybrids. Acta Horticulturae 1082:113-121.

Feechan, A., M. Kocsis, S. Riaz, W. Zhang, D.M. Godoury, M.A. Walker, I.B. Dry, B. Reisch and L. Cadle-Davidson. 2015. Strategies for *RUN1* deployment using *RUN2* and *REN2* to manage grapevine powdery mildew informed by studies of race-specificity. Phytopathology 105:1104-1113.

Walker, M.A. 2015. The Genus *Vitis*, Its Species and Its Rootstocks. IN: Compendium of Grape Diseases, Disorders, and Pests, 2nd Edition, Ed. W.F. Wilcox, W.D Gubler and J.K. Uyemoto et al. American Phytopathology Press.

Amrine, K.C.H, B. Blanco-Ulate, S. Riaz, D. Pap, L. Jones, R. Figueroa-Baoderas M.A. Walker and Cantu, D. 2015. Comparative transcriptomics of Central Asian *Vitis vinifera* accessions reveals distinct defense strategies against powdery mildew. Horticultural Research 2: Article number: 15037 (2015) doi:10.1038/hortres.2015.37

Dangl, G.S., M.L. Mendum, J. Yang, M.A. Walker and J.E. Preece. 2015. Hybridization of cultivated *Vitis vinifera* with wild *V. californica* and *V. girdiana* in California. Ecology and Evolution 5:5671-5684.

Viana, A.P., M.D.V. de Resende, S. Riaz and M.A. Walker. 2016. Genome selection in fruit breeding: application to table grapes. Scientia Agricola 73:142-149.

Pap, D., S. Riaz, I.B. Dry, A. Jermakow, A.C. Tenscher, D. Cantu, R. Olah and M.A. Walker. 2016. Identification of two novel powdery mildew resistance loci, *Ren6* and *Ren7*, from the wild Chinese grape species *Vitis piasezkii*. BMC Plant Biology (In Press)

Xie, X., C.B. Agüero, Y. Wang and M.A. Walker. 2016. Genetic transformation of grape varieties and rootstocks via organogenesis. Plant, Cell, Tissue and Organ Culture (In Press)

PRESENTATIONS

Talks at Grower Meetings (Extension/Outreach) July 2015 to July 2016

Breeding PD and PM resistant winegrapes with tasting. Daniel Roberts Client Group, Santa Rosa, CA July 10

PD resistant wine grapes. Ventura Farm Press Interview, July 7

Breeding PD and PM resistant winegrapes. Sonoma County Winegrape Commission, Santa Rosa, CA July 31

PD resistant winegrapes – talk and tasting California Association of Family Farms, Valley Center, CA Aug 7
Grape breeding at UC Davis. Chilean Table Grape Association, UC Davis, Aug 25
Grape rootstock and scion breeding at UC Davis. North American Grape Breeders Association Meeting, Geneva, NY, Aug 29.
PD Breeding Progress – report and tour. CDFA Administrators, UC Davis Oct 13
Grape breeding at UC Davis Interview for David Pelletier for International Wine Magazine, UC Davis Oct 13
Breeding PD resistant wine grapes – talk and tasting VEN on the Road, Santa Maria, CA Nov 5
UCD vineyard and winery tour, and PD wine tasting with Darrel Corti. Sacramento Private School support group and auction prize, UC Davis Nov 8
PD resistant winegrapes nearing release. FPS Annual Meeting, UC Davis Nov 10
Breeding PD resistant winegrapes. Napa Vit Tech Meeting, Napa, CA Nov 12
Grape breeding at UC Davis. Guest Lecturer at Chihuahua University, Chihuahua, MX Nov 25
Breeding PD resistant winegrapes. UCD Winegrape Day, UC Davis Dec 2
Walker grape breeding program. UC Cooperative Extension Grape Farm Advisor Meeting, UC Davis Dec 3
PD breeding update and tasting. Oak Knoll Growers Group, Napa, CA Jan 7, 2016
Walker grape breeding program update and tasting. Silverado SIMCO Growers Management Seminar, Napa, CA Jan 13, 2016
PD resistant winegrapes – update and tasting Napa/Sonoma growers meeting, Napa, CA Jan 21, 2016
Rootstock and Scion breeding overview. Lodi Grape Day, Lodi, CA Feb. 2 2016
PD resistant winegrape breeding and tasting, Silverado Vineyards meeting, Napa, CA April 4
PD resistant winegrape breeding. Talk and discussion with John Dyson and Williams Salem staff, UC Davis, April 13
PD resistant winegrape breeding and tasting for California Association of Winegrape Growers, Sacramento, CA Apr 18
Breeding PD resistant winegrapes. Temecula Grape Day, Temecula, CA Apr 21
Breeding PD resistant winegrapes. Alan Tenscher presenting to the AVF Board in Livermore, Apr 29
Breeding PD resistant winegrapes. Talk and tasting for Napa winemakers and viticulturists, UC Davis, May 4
Winegrape breeding at UC Davis. Vintage Nursery Open House, Wasco, CA May 18
Winegrape breeding at UC Davis. International Cabernet Sauvignon Conference, Pine Ridge Winery, Napa, CA June 22

Presentations at Scientific Meetings

Xiaoqing Xie, Cecilia B. Agüero, Yuejin Wang, M. Andrew Walker. Optimizing the genetic transformation of grape fruiting and rootstock cultivars. 2016 ASEV National Meeting, Monterey, CA June 29.
Karla Huerta, Summaira Riaz, Alan Tenscher and M Andrew Walker. Characterization of Pierce's disease resistance in germplasm collected from the southwestern US and Mexico. 2016 ASEV National Meeting, Monterey, CA June 29.
Summaira Riaz, Dániel Pap, Alan Tenscher and M. Andrew Walker. Molecular strategies to stack powdery mildew resistance from multiple backgrounds in a grape breeding program. 2016 ASEV National Meeting, Monterey, CA June 29.

RESEARCH RELEVANCE

The goal of this research is two-fold: to produce PD resistant wine grapes that can be used in PD hot spots in California and across the southern US; and to provide breeding, maintenance and screening support for our gene characterization and genetic mapping efforts. We now have hundreds of selections at the 97% *vinifera* level and have begun the process of determining which are most resistant and most suitable for release. Sixteen winegrape selections were sent to FPS last over the past 3 years to be certified and prepared for release; three were added this spring.

STATUS OF FUNDS: These funds are scheduled to be spent by the end of the grant.

INTELLECTUAL PROPERTY: PD resistant varieties will be released through the Office of Technology Transfer (Patent Office) of the University of California, Davis.


Figure 1. Summer 2015 view of the Caymus test plot on the levee near the Napa River.