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Screening and Evaluation of New Rootstocks with Resistance to *Phytophthora cinnamomi*

Continuing Project: Year 14 of 20

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Benefits to the Industry

Ultimately, the control of Avocado root rot will be accomplished with a resistant rootstock. This project has already provided the industry with several new tolerant rootstocks, which are greatly improving the yields of avocado on land infested with *Phytophthora cinnamomi.* The goal is to find a rootstock that will eliminate *Phytophthora cinnamomi* as a serious pathogen on avocado. Our ability to find such a rootstock has been enhanced as a result of our breeding blocks where we focus on crossing already resistant rootstocks.

Objectives

To collect, select, breed and develop avocado germplasm that exhibits resistance to Phytophthora root rot of avocado.

As of July 1, 2005, I have replaced Dr. John Menge as project leader. My first goal over the past two months has been to figure out the over all status of the rootstock breeding program. My objectives over the next year will be to: i) evaluate the overall progress of the program, ii) critically evaluate the analytical methodologies currently used in the program, iii) evaluate areas in which additional technologies may improve the breeding program, and iv) to gain knowledge of the UC patenting process so that valuable root stocks can be delivered to the growers as soon as possible, including varieties that Dr. Menge has been trying to get patented over the past couple of years.

Field Trials

There are currently 26 rootstock varieties that have been developed from this project that are being tested under field conditions throughout the northern and southern avocado growing regions of California (Table 1). Five varieties (Arpaia, Faber, Bender, Mauk, Gray) are in the process of being grafted for field trials next year. Three of the varieties (Zentmyer, Uzi, Steddom) are in the patenting process and one variety (Anita) thus far is a strong candidate to be patented but will require further testing. Thirteen of the varieties are still in the testing phase whereas 18 have been terminated from the program due to poor performance. However, we still have 42 UCR rootstock varieties selected for root rot resistance that have not been tested in the field.

Table 1. Field distribution and status of the UCR rootstocks developed directly from this project.

	Field plots within the avocado growing regions																						
	Southern												Northern										
Rootstocks	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Root stock status**
PP4 Zentmyer	X							X						X		X	X	X	X	X	X	X			Testing done*
PP14 Uzi		X			X		X		X	X							X	X	X	X				X	Testing done*
PP24 Steddom		X					X			X	X						X	X		X	X				Testing done*
PP35 Anita	X						X	X					X	X	X		X	X		X		X	X		Testing**
PP21 Erin														X			X								Testing
PP26 Martin													X		X		X	X							Testing
PP36 Dirac			X		X		X						X	X	X				X						Testing
PP37 Frolic								X					X	X	X					X		X	X		Testing
PP40 Eddie						X	X								X								X		Testing
PP41 Witney			X	X	X	X		X					X	X	X				X	X		X	X		Testing
PP42 Johnson							X																X		Testing
PP43 Campbell				X						X										X					Testing
PP45 Brandon																							X		Testing
PP47 CI #2			X	X	X					X									X						Testing
PP52 Downer			X		X	X													X						Testing
PP22 Medina												X													Testing
PP5 Berg			X		X						X														Terminated
PP15 Guillemet												X									X				Terminated
PP16 Rio Frio			X	X	X					X	X								X						Terminated
PP18 Afek		X			X				X	X									X				X		Terminated
PP19 McKee												X							X		X				Terminated
PP28 Elinor							X						X		X										Terminated
PP29 Pond	X							X					X	X					X		X	X			Terminated
PP33 Margy	X							X					X	X				X				X			Terminated
PP34 Crowley	X							X						X							X	X			Terminated
PP44 Fred	X						X	X		X												X			Terminated
PP48 Arpaia																									In preparation
PP49 Faber																									In preparation
PP50 Bender																									In preparation
PP51 Mauk																									In preparation
PP25 Gray																									In preparation

* In patenting process

** Strong candidate for next patent

Within our field trials, we also have rootstock varieties from South Africa (Dusa and Latas) and Israel (VC lines) as well as previously developed rootstocks (Table 2). The South African varieties show good tolerance to root rot as does Toro Canyon and some of the VC lines. However, there are also additional VC lines that have not been tested and Chilean material is now under quarantine and will be tested once this process is completed.

It is difficult to summarize the field trial data in any really meaningful way. For example, there are currently 24 field plots that were planted at various times (approximately one to six years old), with different varieties, under different management practices, with different disease pressure as well as soil characteristics (depth, salinity, slope). However, when visiting a field plot with one of our varieties that has good resistance, the results are easy to see. Trees planted into root rot infested soils that are resistant grow well and are starting to produce well, whereas the varieties that are not resistant do very poorly (Table 3).

Table 2. Field distribution of additional rootstock varieties not developed from this

project.

	Field plots within the avocado growing regions																							
	Southern												Northern											
Rootstocks	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Thomas*	X			X		X	X	X	X	X		X		X	X		X	X	X	X	X	X		
Merensky II (Dusa)			X		X														X		X		X	X
Merensky I (Latas)		X														X	X							
Duke 7											X		X			X								
Parida	X										X													
Topara				X																				
Toro Canyon		X					X																	
VC44		X									X													
VC207		X			X					X	X								X					
VC218	X		X								X													X
VC225		X			X				X															
VC241		X			X														X					
VC801	X		X		X	X			X		X													
VC256						X			X															
Spencer										X													X	
UC2035										X														
Duke 9								X									X		X		X	X		

* Standard control variety

Table 3. Fruit yield of ‘Hass’ avocados growing on various rootstocks in Escondido, CA (Feb and June 2005).

Rootstock	Fruit weight per tree (kg)	Individual fruit weight (kg)
Merensky II (Dusa)	38.61a	0.24 a
Uzi	31.78 ab	0.24 a
Merensky I (Latas)	30.73 abc	0.23 a
Steddom	28.87 abcd	0.25 a
Duke 7	16.04 bcde	0.27 a
Leo	15.42 bcde	0.24 a
Zentmyer	14.75 bcde	0.30 a
VC241	14.19 bcde	0.26 a
Thomas	13.44 bcde	0.26 a
Spencer seedling	11.58 bcde	0.26 a
G755A	11.56 bcde	0.21 a
Poly N	10.47 cde	0.21 a
Rio Frio	9.44 de	0.24 a
Spencer clonal	8.24 e	0.26 a
Guillemet	6.26 e	0.30 a

Mean values in each column followed by identical letters are not statistically different based on Waller’s K-ratio t test.

Breeding Blocks

One of the key features of this program is to consistently select the best varieties that show tolerance to root rot and continually plant them into breeding blocks. The objective is to then select and screen progeny from these blocks with the hope that a better

rootstock variety will be found. This is the best possible way to maximize the potential additive effect of genetically inherited traits that may confer resistance to *P. cinnamomi*.

The breeding blocks are now made up of Merensky I, Merensky II, VC 256, G755A, Thomas, G810, Toro Canyon, Spencer, Barr Duke, UC2001, CRI-71, Duke 7, G6, D9, UC2011, Zentmyer, *Persea steyermarkii Persea nubigena,* Aguacate de Anis, Aguacate de mico, Berg, Uzi, Guillemet, Rio Frio, Afek, McKee, Erin, Medina, Steddom, Martin, Elinor, Pond, Dirac, Eddie, Witney, Johnson, Faber, Bender, Mauk, Downer, Turney, Janice, Gabor, Mary Lu, Lovatt, VC 207 and VC 218. Future blocks will be set up using our most resistant rootstocks only such as Merensky I & II, Uzi, Steddom, Anita, & Toro Canyon.

I am also planning on using some of the molecular markers developed by Clegg's group as well as additional molecular markers to learn something about the parentage of the varieties from the breeding blocks. For example, previous research has shown that some pollen donors are better than others. For example, Sulaiman, *et al.* (2004) found that a minimum of 46% and a maximum of 85% of embryos from the variety 'Gwen' were pollinated by the variety 'Ryan'. This was true even in cases where a 'Ryan' donor was up to 50 m away from a 'Gwen' tree that was surrounded by other varieties. Thus, it would be important for us to know if one or more of our resistant rootstocks were preferentially the pollen donors so that breeding blocks could be set up to maximize genetic exchange among all the best resistant rootstock varieties.

In 2003, a new breeding block for salt resistance was established at Agricultural Operations in Riverside. Varieties in this salt block include Merensky I, Merensky II, Toro Canyon, VC 207, VC 208, and VC 801. Seeds from this block will be harvested and planted on to a strip of land donated by Harlan Beck in Escondido, CA. He will water these trees with extremely salty water, and after two years, salt resistant varieties will be harvested and returned to Riverside for cloning and further testing. In the meantime, seeds from additional VC lines from the South Coast Field Station have been planted into this salt resistance field plot. In 2004, a new plot consisting of potential dwarfing material was set up in Agricultural Operations at UCR. This plot contains the varieties Wilig (South Africa), Erin (PP 21 maternal parent D9), Frolic (PP37 maternal parent D9) and Witney (PP41 maternal parent D9).

Greenhouse Evaluation of Rootstocks

In the 2003/2004 greenhouse screening experiments, four rootstocks were tested along with the standard cultivar 'Thomas'. No significant differences were detected for the amount of healthy roots but were for root and shoot weight, root length, and trunk diameter between some of the varieties (Table 4). None of the rootstock varieties appeared to be really strong candidates for future testing. However, after examining the greenhouse data from previous years, it is difficult to make a prediction. For example, in last year's greenhouse screening, 'Elinor' showed good root rot resistance but has since been terminated due to poor field performance. I am therefore in the process of evaluating the data from past greenhouse experiments to see if good predictions can be

made based on these tests. If predictions cannot be made, then we may need to change the screening process or eliminate this from the program. If we do eliminate this step, more time could then be freed up for performing other duties such as screening more seed and testing more rootstock varieties in field plots.

Table 4. Results from the 2003/2004 greenhouse experiments to screen for root rot resistance.

Rootstock	Healthy roots (%)	Root weight (gm dry wt)	Shoot weight (gm dry wt)	Root length (cm)	Trunk diameter (mm)
Martin	79.2a	27.3ab	67.2a	969.7b	3.6a (increase)
Frolic	73.3a	19.5b	40.3b	730.7c	1.2c (increase)
Thomas	70.9a	35.0a	73.1a	1238.4a	3.4ab (increase)
Margy	67.5a	21.7b	45.7b	641.9c	2.3bc (increase)
Campbell	59.0a	15.5b	47.5b	750.3bc	3.7a (increase)

One explanation for the potential unpredictability of the greenhouse screening is the current protocol used. Currently, rootstock varieties are screened without grafting a 'Hass' scion. Since the physiology of the tree may change once a scion has been grafted, we need to control for this by testing rootstock varieties with and without a grafted scion. Therefore, this year we are adding a control with a grafted 'Hass' scion. If there are significant differences between the grafted and ungrafted treatments, then a change in the screening process must occur or be terminated.

Conclusions

It appears that we have several rootstocks that are consistently performing better than our standard resistant variety, Thomas, under root rot conditions. These are Uzi (PP14-maternal parent G6), Merensky I (Latas -South Africa), and Steddom (PP24-maternal parent Toro Canyon). Zentmyer (PP4- maternal parent Barr Duke) is also growing well but is sensitive to salt. We are preparing to release these 4 rootstocks to growers. There are also other rootstocks, such as Anita (PP35 maternal parent UC 2001), which appear to be showing promise. Erin (PP21 maternal parent D9) appears to dwarf Hass avocado but we still need more time to evaluate this in case it is an incompatibility issue. If it does appear to be a dwarf, it might be useful for dense plantings, backyard trees, or for a pollinator variety. Witney (PP 41 maternal parent D9) and Frolic (PP 37 maternal parent D9) are slow growing varieties that set fruit quickly and stay relatively small. These may also be potentially used for dense plantings. We also have 42 additional lines that have been selected from our breeding blocks and additional blocks will be set up with our most resistant lines in hopes of attaining even better varieties in the future.

Reference

Sulaiman, Z., Collins, G., Witherspoon, J. and Sedgley, M. 2004. Identification of pollen donors for the avocado cultivar Gwen in a mixed orchard by isozyme analysis. *Journal of Horticultural Science & Biotechnology* 79: 571-575.