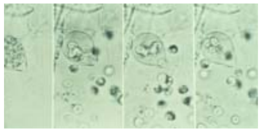
Screening and Evaluation of New Rootstocks with Resistance to *Phytophthora cinnamomi 2006*



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Overview

Avocado root rot, caused by *Phytophthora cinnamomi*, is the most destructive and yield limiting disease of avocado world-wide. The most effective way to control this disease is to develop rootstocks that are resistant to the pathogen. This project, initiated by John Menge over a decade ago, has already provided the industry with several new disease tolerant rootstocks, which are greatly improving the yields of avocado on land infested with *P. cinnamomi*. The goal is to find a rootstock that will eliminate *P. cinnamomi* as a serious pathogen on avocado.

Since 1989, over 45,000 seedlings have been screened for root rot resistance and aproximately 2,500 have begun to be screened in 2006. Over 60 rootstocks have made it through the initial root rot resistance screening in the greenhouse. There are currently 22 rootstock varieties that have been developed from this project that are currently being tested under field conditions throughout the northern and southern avocado growing regions of California (Table 1). Seven varieties have been terminated from the program due to poor performance as well as 2 VC lines. We are also testing additional rootstocks that were not developed in this current research project (Table 1). Three new field plots were set up this year; two in the northern growing region and one in the southern growing region. Three new rootstocks (PP56, PP58, & PP63) were added to the field plots this year. For next year, this will be increased to aproximately 6 new rootstocks developed from this program and 4 from 'escape' trees growing in *Phytophthora* infested soil. However, we still have approximately **forty** untested UCR rootstocks that showed resistance to *P. cinnamomi* in the initial two-year greenhouse screening process.

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 will be found. Since some pollen donors in avocado are better than others, we also plan on studying the parentage of the varieties from the breeding blocks. This information will enable us to set up appropriate breeding blocks to maximize genetic exchange among all the best resistant rootstock varieties. We will accomplish this by utilizing molecular markers such as amplified fragment length polymorphisms (Fig. 1) and microsatellite markers that were developed by CAC funded research in the laboratory of M. Clegg (UC Irvine).

2006 Yield Data

Four field trials were harvested this year. Only one field plot was considered to be heavily infested with *Phytophthora cinnamomi* (Table 2). Under these conditions, our resistant rootstocks Zentmyer, Uzi and Steddom produced 51.75, 43.66, and 41.00 kg/tree, respectively (Table 2). In the previous two years, the Thomas control trees only produced approximately 15 kg/tree. The Thomas trees were not harvested in 2006 due to a communication error, but it is obvious that our rootstocks are doing much better under these harsh conditions than Thomas. The South African varieties, Dusa and Latas, also produced significantly more than the Thomas controls (also based on 2004/2005 yield data). However, in field plots with little to moderate disease, the differences between rootstocks were not as obvious. For future evaluations, it will be important to have field plots with as much disease pressure as possible.

Table 2. 2006 yield data, disease pressure, and age of 3 out of 4 plots that were harvested this year..

Fallbrook, April 2006	**Little diesease pressure**	**4 year old plot**
Rootstock	Total fruit weight (kg)	Individual fruit weight (kg)
Witney	36.62a	0.229a
Crowley	35.43ab	0.221a
Anita	34.51ab	0.231a
Thomas	30.66abc	0.232a
Pond	30.48abc	0.234a
Zentmyer	29.74abc	0.223a
Margy	29.05abc	0.237a
Duke 9	28.45bc	0.241a
Fred	27.79bc	0.233a
Frolic	23.28c	0.237a
Rancho Ca, April 2006	**Moderate diesease pressure**	**4 year old plot**
Rootstock	Total fruit weight (kg)	Individual fruit weight (kg)
VC801	27.55a	0.173abc
Afek	21.56ab	0.194a
VC256	16.49b	0.157c
Thomas	13.19b	0.189ab
VC225	11.41b	0.159bc
Escondido, May2006	**Heavy diesease pressure**	**6 year old plot**
Rootstock	Total fruit weight (kg)	Individual fruit weight (kg)
Merensky II (Dusa)	53.24 a	0.18 a
Zentmyer	51.75 a	0.22 a
Merensky I (Latas)	50.46 a	0.23 a
Uzi	43.66 a	0.19 a
Steddom	41.00 a	0.20 a
VC241	27.96 a	0.20 a

Table 1. Field distribution and status of the current rootstocks that are being field tested for root rot resistance. The year indicates when the field was planted and the X's denote the rootstocks that are in a particular field.

Southern CA

Rootstocks	**1 (2002)**	**2 1(2003)**	**3 2(2005)**	**4 (2005)**	**5 (2006)**	**6 (2005)**	**7 (2000)**	**8 (2003)**	**9 (2002)**	**10 (2002)**	**11 (2004)**	**12 (2003)**
Thomas	X	X				X	X	X	X	X	X	
Merensky II (Dusa)			X	X	X		X					
Merensky I (Latas)		X					X					
Duke 7							X					X
Parida	X											X
Topara												
Toto Canyon		X						X				
VC44		X										X
VC207		X		X							X	X
VC218	X		X									X
VC225		X		X						X		
VC241		X		X			X					
VC801	X		X	X		X				X		X
VC256						X				X		
Zentmyer PP4	X						X		X			
Berg PP5			X	X								X
PP14 Uzi		X		X			X	X		X	X	
PP15 Guillemet							X					
PP16 Rio Frio			X	X			X				X	X
PP18 Afek		X		X						X	X	
PP19 McKee												
PP21 Erin												
PP22 Medina												
PP24 Steddom		X					X	X			X	X
PP26 Martin												
PP28 Elinor								X				
PP29 Pond	X								X			
PP33 Margy	X								X			
PP34 Crowley	X								X			
PP35 Anita	X							X	X			
PP36 Dirac			X	X				X				
PP37 Frolic									X			
PP40 Eddie					X	X		X				
PP41 Witney			X	X		X			X			
PP42 Johnson								X				
PP43 Campbell											X	
PP44 Fred	X							X	X		X	
PP45 Brandon					X							
PP47 CI #2			X	X							X	
PP52 Downer			X	X		X						
PP56 Gabor												
PP58 Lovatt												
PP63 O'Connell					X							
SA-1 Lansfield					X							
Spencer											X	
UC2035											X	
Duke 9									X			
Number of trees	200	200	180	260	100	120	300	200	200	100	200	200
Disease Pressure	1	2	2	1	?	2	3	1	1	2	3	2

Northern CA

Rootstocks	**13 (2004)**	**14 (2004)**	**15 (2004)**	**16 (2005)**	**17 (2003)**	**18 (2003)**	**19 (2003)**	**20 (2006)**	**21 (2003)**	**22 (2001)**	**23 (2006)**	**24 (2002)**	**25 (2005)**	**26 (2005)**
Thomas		X	X		X	X	X	X	X	X		X		
Merensky II (Dusa)							X	X		X	X		X	X
Merensky I (Latas)				X	X									
Duke 7	X			X										
Parida														
Topara											X			
Toro Canyon														
VC44														
VC207							X							
VC218														X
VC225														
VC241							X							
VC801														
VC256														
Zentmyer PP4		X		X	X	X	X		X	X	X	X		
Berg PP5														
PP14 Uzi					X	X	X	X	X		X			X
PP15 Guillemet										X				
PP16 Rio Frio							X	X			X			
PP18 Afek							X	X			X		X	
PP19 McKee							X			X				
PP21 Erin		X			X			X			X			
PP22 Medina								X			X			
PP24 Steddom					X	X			X	X				
PP26 Martin	X		X		X	X								
PP28 Elinor	X		X											
PP29 Pond	X	X					X			X		X		
PP33 Margy	X	X				X						X		
PP34 Crowley		X								X		X		
PP35 Anita	X	X	X		X	X			X			X	X	
PP36 Dirac	X	X	X				X							
PP37 Frolic	X	X	X						X			X	X	
PP40 Eddie			X					X			X		X	
PP41 Witney	X	X	X				X		X			X	X	
PP42 Johnson								X			X		X	
PP43 Campbell									X		X			
PP44 Fred												X		
PP45 Brandon								X			X		X	
PP47 CI #2							X							
PP52 Downer							X							
PP56 Gabor								X			X			
PP58 Lovatt								X			X			
PP63 O'Connell								X						
SA-1 Lansfield								X						
Spencer													X	
UC2035														
Duke 9					X		X			X		X		
Number of trees	200	200	180	180	180	140	200	300	160	180	280	200	160	80
Disease Pressure	2	2	1	1	2	1	2	3	1	1	3	1	3	3

1 = low
2 = medium
3 = high

bold = not being further tested

Total of 4900 trees planted

Conclusions and Future Directions

There are two immediate improvements that are being made to increase the success of the breeding program. First, we will drop out varieties quicker that do not appear to have any tolerance to root rot. Secondly, all new plots that are selected need to have a heavy inoculum load. Many of our current trials do not have root rot in the soils, which defeats the purpose of screening for resistance. Once we find potential rootstocks that show promise, then we can plant them in soil that is free of the disease to evaluate yield effects. This will be done, even if it means having fewer field trials. We need good trials, not just as many as possible. Molecular tools will help us in the rootstock breeding selection and new breeding blocks will continually be planted with the most promising varieties and the weak varieties will be taken out of the breeding blocks. We are also continuing collaborations with other researchers to find better germplasm for root rot resistance (Fig. 2).

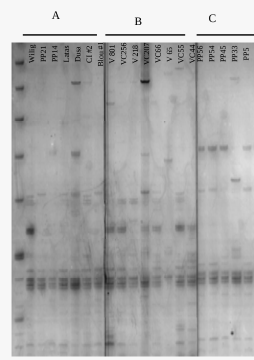

Figure 1. Amplified fragment length polymorphism gel image with various rootstock varieties: A) South African varieties, some of our PP lines, and one escape tree. B) Putative salt tolerant Israeli VC lines. C) Duke9 and 5 lines derived from a parent Duke 9 tree. Polymorphism within PP33 indicates out crossing from some other variety. Shared polymorphic band (upper arrow) with VC207 and Dusa indicates they are potential pollen donors but more data would be needed to statistically verify this due to the small sample size. Lower polymorphic band indicates a potential rootstock specific marker that could be used in parentage analysis. However, significantly more data would be needed to verify this. This gel is just an example of how DNA polymorphisms can be used to understand overall genetic variation and parentage relationships among rootstocks.

Figure 2. Evaluations of rootstocks in South Africa. This photo is from a recent trip to South Africa where I visited Westfalia Agribusiness. The purpose of the trip was to continue the collaboration between UC and Westfalia for rootstock breeding. Below you can see two rootstocks showing significant differences with respect to root rot symptoms. The healthy tree on the left has a Zentmyer rootstock whereas the one plant on the left is highly susceptible. The researchers at Westfalia noted that they are really interested in Zentmyer because it appears to do very well there.

Funding from the California Avocado Commission (CAC) and support from California growers who donate valuable land for field trials is greatly appreciated.