

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

Continuing Project; Year 9 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 which exhibits resistance to *Phytophthora* root rot of avocado.

Summary

Collection and Selection of Germplasm

We have obtained one new “escape” tree called the Hortin. This tree appeared to have survived a field epidemic of avocado root rot.

Breeding Program

We have screened 3801 seeds from the breeding blocks for resistance to *Phytophthora cinnamomi* in 2000. We have retained 21, which showed a high degree of resistance. Most of these varieties had maternal parents D9, G6 or UC2001. While we can handle up to 12,000 seeds per year, we have begun to revamp one of the 9 breeding blocks every year. Resistant trees will be planted in the blocks instead of grafting resistant buds into existing trees. This will allow more uniform plantings, the establishment of replicated trees and prevent shading and suppression of slower growing germ plasm. We now have 47 seedlings from the breeding blocks, which have shown exceptional resistance to *Phytophthora cinnamomi* after extensive testing. Twelve of these are being field-tested, five more are being grafted for field tests in 2002. Sixteen more are ready for field-testing and fourteen have been grafted to increase budwood in 2001.

We are attempting to synchronize the flowering in the avocado breeding blocks so that varieties flowering at different times have a higher probability of crossing. We have experimented with a program of girdling late varieties (*Persea steyermarkii*, CRI-71, G810, G755) and spraying early varieties (Thomas, Toro Canyon, Barr Duke, Duke 7, and UC2011) with Uniconazole-P. Three year's results indicate no significant alterations in the flowering times or fruit set due to these treatments. We have decided to discontinue these treatments. Instead we are hand pruning the early flowers from some of the early flowering trees. This results in a later production of axillary flowers, which may coincide with the bloom of later varieties. We covered trees in some of the blocks and are using beehives in an

attempt to get more crosses between varieties. Results from Dr. Clegg's lab will verify if indeed the captive bees result in more crosses. We are also examining the possibility of harvesting early pollen and allowing the bees to spread it to later blooming varieties.

We are cooperating with Dr. Clegg to determine how many of our rootstocks from the breeding blocks are actually crosses and how many are selfs. With some of the early data now in, we are able to show that at least 25% of the first 12 breeding block rootstocks are indeed crosses. We have been able to determine the complete parentage of only two of the selected rootstocks from the breeding blocks, which show a high degree of resistance. The problem is that D9, UC 2001, and Barr Duke, which are progeny of Duke 7, and apparently Thomas are closely related and difficult to differentiate using the limited number of microsatellite markers now available to Dr. Clegg. Spencer, G6, Toro Canyon, G755 and G 810 are not related and are easily differentiated. Dr. Clegg is trying to obtain more microsatellite markers to further differentiate rootstocks in our breeding blocks.

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 and *Persea steyermarkii*.

Screening and Greenhouse Evaluation of Rootstocks

Extensive greenhouse trials with VC 239 (West Indian, Israel), VC 241 (West Indian, Israel), Erin (PP21, breeding block, maternal parent D9), Afek (PP18, breeding block, maternal parent Thomas) and Thomas, indicated that all four tested rootstocks were more resistant to *Phytophthora cinnamomi* than was Thomas. Afek built up higher populations of *P. cinnamomi* in the rhizosphere than did Erin, VC 241 or VC 239. Only VC 241 had lower populations of *P. cinnamomi* in the rhizosphere than Thomas. Very low numbers of *P. cinnamomi* zoospores were attracted to the Erin, Afek, VC239 and VC 241 when compared to Thomas. Rootstocks selected for intensive testing in 2001 include Martin (PP26, maternal parent D9), Pond (PP29, maternal parent G6), Crowley (PP34, maternal parent UC2001), Thomas and Borchard. Plants being grafted for intensive studies in 2002 include Elinor (PP28, maternal parent D9), Margy (PP33, maternal parent D9), Anita (PP35, maternal parent UC2001), Dirac (PP36, maternal parent UC 2001), Thomas and Borchard.

Field Evaluation

We now have 30 field trials (4,390 trees) testing 46 clonal root rot tolerant rootstocks throughout Southern California. The following are brief summaries of the older trials.

In an 10- year-old rootstock trial at South Coast without heavy root rot pressure, the trees yielded in the following order from greatest to least: Merensky II (Dusa-South Africa), Duke 7, Thomas, UC2003 (Escondido), Borchard, D9 (irradiated Duke), Queretaro (Mexico), Spencer (Pauma Valley), UC2011 (Duke-Statom), CRI-71 (Costa Rica). However for the seven year average (1995-2001) the rootstocks yielded in the following order from greatest yield to least yield: , Merensky II (Dusa-South Africa), Duke 7, UC2003 (Escondido), Borchard, Thomas, D9 (irradiated Duke), Queretaro (Mexico), UC2011 (Duke-Statom), Spencer, and CR 1-71(Costa Rica).The Merensky II (Dusa-South Africa) has been released to nurseries this year and the UC 2003 should be studied in future tests. Only the CR 1-71 (Costa Rica) is performing poorly enough to be eliminated from study.

A 5-year-old trial at Goleta, CA under heavy root rot pressure was rated as follows from healthiest to poorest: Merensky III (Evstro –South Africa), Spencer (Pauma Valley), G755A (*P. schiedeana* x *P. americana* seedling), and Velvick (Australia). Tree size from largest to smallest was: G755A (*P. schiedeana* x *P. americana* seedling), Merensky III (Evstro –South Africa), Spencer (Pauma Valley), and Velvick (Australia). Only Velvick is doing poorly in this trial.

In a 5-year-old trial in Camarillo, CA under heavy root rot pressure, trees yielded as follows from the greatest to least: VC 256 (Israel), Thomas, Borchard, Spencer (Pauma Valley), UC 2014 (W-14 South Africa), Merensky III (Evstro -South Africa), Gordon (South Africa), UC 2023 (G755 C seedling) and Halma Duke. Tree size from largest to smallest was: Thomas, VC 256 (Israel), Borchard, Merensky III (Evstro –South Africa), UC 2014 (W-14 South Africa), Gordon (South Africa), Spencer (Pauma Valley), UC2023 (G755 C seedling), and Halma Duke. All of the varieties seem to be doing well except for Borchard. Yields were low this year and so differences between varieties

were not large. Nutrient analysis from this plot indicates no rootstock effect on leaf concentrations of nitrogen, potassium, sodium, copper and iron. It appears that VC 256 has elevated levels of phosphorous in leaves while Borchard, Evstro, Gordon, Spencer, Thomas and UC 2014 have lower levels of phosphorous in the leaves. It appears that VC 256 and UC 2014 result in elevated levels of calcium in leaves while Halma Duke and Thomas have lower levels of calcium. UC 2014 has higher levels of magnesium in its leaves than most of the other rootstocks. VC 256, Evstro, and Gordon result in higher levels of Zn than most other rootstocks. Thomas, which had high levels of Zn in its leaves last year, had the lowest levels this year. UC 2023 and Halma Duke had the lowest levels of manganese in their leaves. In this trial phosphorous appears deficient for all rootstocks. Only UC 2014, UC 2023 and VC 256 had optimal calcium levels in the leaves, and only Evstro, Gordon, Spencer, UC2023 and VC 256 had optimum levels of Zn in their leaves.

A 4-year-old trial in Somis, CA under heavy root rot pressure, was rated as follows from the healthiest to the poorest: Thomas, Spencer (Pauma Valley), Merensky III (Evstro-South Africa), and Velvick (Australia). Tree sizes from largest to smallest were: Thomas, Spencer (Pauma Valley), Merensky III, Velvick (Australia) and Merensky III (Evstro -South Africa). Only Velvick is doing poorly in this trial.

A 3-year old trial in Somis, CA under heavy root rot pressure was rated as follows from healthiest to the poorest: Berg (PP5 -maternal parent D9), Zentmyer (PP4- maternal parent Barr Duke), Merensky III (Evstro -South Africa), Thomas, G755A(*P. schiedeana* x *P. americana* seedling) and Duke 7. Tree sizes from largest to smallest were: Berg (PP5-maternal parent D9), Zentmyer (PP4- maternal parent Barr Duke), G755A(*P. schiedeana* x *P. americana* seedling), Thomas, Merensky III (Evstro-South Africa), and Duke 7. Only Duke 7 is doing poorly in this plot. Yield from greatest to least was as follows: Merensky III (Evstro- South Africa), Duke 7, Berg (PP5 -maternal parent D9), Zentmyer (PP4- maternal parent Barr Duke), Thomas, and G755A(*P. schiedeana* x *P. americana* seedling). Yield was light on this plot so differences between rootstocks was small. Leaf analysis from this plot indicated that there were no differences in leaf concentrations of nitrogen, phosphorous, potassium, zinc, or copper due to rootstock. However, Duke 7 had the highest leaf concentrations of calcium while Zentmyer had the lowest. Duke 7 and G755A had the highest levels of magnesium while Berg had the lowest. Merensky III had the highest levels of sodium in the leaves while Thomas had the lowest. Berg had the highest levels of manganese while G755A and Zentmyer had the lowest. Thomas had the highest levels of iron in the leaves while Merensky III had the lowest. In this trial all trees had less than optimum levels of phosphorous and copper. Only Thomas and Duke 7 had optimum levels of calcium.

A 3-year old trial established in Carpinteria CA in salty soil under heavy root rot pressure was rated as follows from healthiest to the poorest: Merensky II (Dusa- South Africa), Zentmyer (PP4- maternal parent Barr Duke), Thomas, and VC 256 (West Indian-Israel). Tree sizes from largest to smallest were: Merensky II (Dusa- South Africa), Zentmyer (PP4- maternal parent Barr Duke), Thomas, and VC 256 (West Indian-Israel). A few VC 207 (Day –West Indian -Israel) were planted at this site and they have virtually no salt damage. Merensky II (Dusa- South Africa) also seems quite resistant to salt damage while Zentmyer (PP4- maternal parent Barr Duke), Thomas, and VC 256 (West Indian-Israel) exhibited heavy salt damage. VC 256 (West Indian- Israel) was supposed to be quite resistant to salt damage but it was not evident in this plot. Only the Merensky II is performing well in this plot.

A 3-year old trial established in Carpinteria under heavy root rot pressure was rated as follows from healthiest to the poorest: Spencer (Pauma Valley), G755A(*P. schiedeana* x *P. americana* seedling), Thomas. Tree sizes from largest to smallest were: G755A(*P. schiedeana* x *P. americana* seedling), Spencer (Pauma Valley), Thomas. Only Thomas is performing poorly at this site.

A 3-year old trial established in Escondido, CA on root rot infested soil. It rated as follows from healthiest to poorest: Zentmyer (PP4- maternal parent Barr Duke), Thomas, Aguacate de Mico (Guatemala). Tree sizes from largest to smallest were: Zentmyer (PP4- maternal parent Barr Duke), Thomas, Aguacate de Mico (Guatemala). Aguacate de Mico is doing very poorly and will not be studied further.

A 3-year old trial established in Temecula CA on root rot infested soil. It rated as follows from healthiest to poorest: Zentmyer (PP4- maternal parent Barr Duke), Toro Canyon, Thomas, Merensky III (Evstro-South Africa), and Duke 7. Tree sizes from largest to smallest were: Thomas, Zentmyer (PP4- maternal parent Barr Duke), Merensky III (Evstro-South Africa), Toro Canyon, Duke 7. Only Duke 7 is failing in this plot.

A 3-year old trial established in Escondido, CA on root rot infested soil. It rated as follows from healthiest to poorest (See Table 1): Merensky I (Latas-South Africa), Zentmyer (PP4- maternal parent Barr Duke), Merensky II (Dusa-South Africa), Rio Frio (Guatemala), VC 241 (Israel), Uzi (PP14-maternal parent G6), VC 241 (Israel), Thomas, Steddom (PP24-maternal parent Toro Canyon), G755A(*P. schiedeana* x *P. americana* seedling), Spencer seedling (Pauma Valley), Leo (Brokaw selection), Guillemet (PP15-maternal parent Thomas), Spencer (Pauma Valley), Duke 7 and Poly N (polyploid, UCLA). Tree sizes from largest to smallest were: Uzi (PP14-maternal parent G6), Merensky I (Latas-South Africa), Steddom (PP24-maternal parent Toro Canyon), Merensky II (Dusa- South Africa), , Spencer seedling (Pauma Valley), Thomas, Zentmyer (PP4-maternal parent Barr Duke), G755A(*P. schiedeana* x *P. americana* seedling), Rio Frio (Guatemala), VC 241 (Israel), Guillemet (PP15-maternal parent Thomas), Leo (Brokaw selection), Duke 7, Spencer (Pauma Valley), and Poly N (polyploid UCLA). Only Poly N and Duke 7 are performing poorly in this trial.

A 3-year old trial established in Carpinteria, CA on root rot infested soil. This trial experienced some water stress in the past year. It rated as follows from healthiest to poorest: Uzi (PP 14, maternal parent G6), Zentmyer (PP4- maternal parent Barr Duke), Merensky II (Dusa- South Africa), Thomas, Merensky I (Latas-South Africa), Merensky III (Evstro-South Africa), Mckee (PP19-maternal parent UC 2001), Merensky IV (South Africa), Poly N (polyploid UCLA), and Aguacate de Mico (Mexico). Tree sizes from largest to smallest were: Uzi (PP14-maternal parent G6), Merensky II (Dusa-South Africa), Zentmyer (PP4-maternal parent Barr Duke), Merensky I (Latas-South Africa), Thomas, Merensky IV (South Africa), Merensky III (Evstro-South Africa), Mckee (PP19-maternal parent UC 2001), Aguacate de Mico (Mexico), and Poly N (polyploid –UCLA). Only Uzi, Zentmyer, and Merensky II are performing well in this trial.

A 3-year old trial established in Escondido, CA on root rot infested soil. It rated as follows from healthiest to poorest: Leo (Brokaw selection), Merensky III (Evstro- South Africa), Thomas, Merensky IV (South Africa), Poly N (polyploid UCLA). Tree sizes from largest to smallest were: Thomas, Merensky III (Evstro- South Africa), Leo (Brokaw selection), Merensky IV (South Africa), and Poly N (polyploid UCLA). None of the rootstocks in this study were performing well and the plot has been terminated.

Eight new field trials were established in 2001. These field trials include Merensky II (Dusa, South Africa), Merensky I (Latas, South Africa), Parida (Brokaw selection), VC 207 (Day-West Indian, Israel), UC 2001 (Duke 7 seedling), UC 2011 (Duke 7 seedling), Merensky III (Evstro-South Africa), Toro Canyon (Brokaw selection), G755A(*P. schiedeana* x *P. americana* seedling), Leo (Brokaw selection), D9 (Irradiated Duke 7 seed), Barr Duke (Duke 7 seedling), Bailard (Brokaw selection), Spencer (Pauma Valley), Pond (PP29, maternal parent G6), Elinor (PP28, maternal parent D9), Zentmyer (PP 4, breeding block, maternal parent Barr Duke), Berg (PP5, breeding block, maternal parent D9), Guillemet (PP15, breeding block, maternal parent Thomas), Mckee, (PP19, breeding block, maternal parent UC2001), Medina (PP22, breeding block, maternal parent Thomas), Steddom (PP 24, breeding block, maternal parent Toro Canyon), VC 256 (West Indian from Israel), UC 2003 (escape tree from Escondido), Afek (PP18, breeding block, maternal parent Thomas), Erin (PP 21, breeding block, maternal parent D9), Crowley (PP34, breeding block, maternal parent UC 2001), Uzi (PP14, breeding block, maternal parent G6), Thomas and Parida (Brokaw selection).

Avocado rootstock varieties being propagated for planting in 2002 include: Pond (PP29, maternal parent G6), Margy (PP33, maternal parent D9), Crowley (PP34, breeding block, maternal parent UC 2001), Anita (PP35, maternal parent UC2001), Frolic (PP37, maternal parent D9), Witney (PP41, maternal parent D9), Fred (PP44, maternal parent UC 2001), VC 44 (West Indian, Israel), Merensky I (Latas- South Africa), VC 225 (West Indian-Israel), VC 256 (West Indian-Israel), VC 801 (West Indian-Israel), Berg (PP5, maternal parent D9), Uzi (PP14, breeding block, maternal parent G6), Guillemet (PP15, breeding block, maternal parent Thomas), Afek (PP18, breeding block, maternal parent Thomas), Mckee (PP19, maternal parent UC 2001), Erin (PP 21, breeding block, maternal parent D9), Medina (PP22, breeding block, maternal parent Thomas), Steddom (PP 24, breeding block, maternal parent Toro Canyon), Elinor (PP28, maternal parent D9).

Conclusions

It appears that we have several rootstocks that are consistently performing better than our standard resistant variety, Thomas. These are Uzi (PP14-maternal parent G6), Merensky I (Latas –South Africa), Merensky II (Dusa- South Africa) and Steddom (PP24-maternal parent Toro Canyon). Zentmyer (PP4- maternal parent Barr Duke) is also growing well but shows some saltburn. The Uzi seems very precocious and it may be nearly double the size of many standard varieties after three years. We have obtained some of our first yield results for many of the new rootstocks. Merensky II appears to provide excellent yields and has been released to growers. Merensky III also seems to yield well. Zentmyer’s initial yields on young trees are mediocre and similar to that of Thomas. More yield data must be gathered on the new varieties before they can be released. Because of the success of our first UCR breeding plot material we are increasing our efforts with these varieties.

Table 1. Avocado rootstock ratings after 3 years in a root rot soil near Escondido CA. ¹

| Rootstock | Tree rating (0-5; 5=dead) | Canopy volume (cu ft) | Trunk diameter (cm) | Percent dead trees |
|----------------|------------------------------|--------------------------|------------------------|-----------------------|
| Merensky I | 0.03 e | 117.09 b | 4.70 ab | 0.0 |
| Zentmyer | 0.23 de | 77.27 cde | 4.39 ab | 0.0 |
| Merensky II | 0.24 de | 95.36 bcd | 4.26 abc | 0.0 |
| Rio Frio | 0.26 de | 68.53 cdef | 3.88 bcd | 0.0 |
| VC 241 | 0.28 de | 61.78 def | 3.79 bcd | 0.0 |
| Uzi | 0.29 de | 163.21 a | 5.14 a | 5.88 |
| Thomas | 0.32 cde | 84.48 bcde | 4.29 abc | 5.88 |
| Steddom | 0.44 cde | 100.40 bc | 3.98 bcd | 6.25 |
| G755A | 0.88 bcde | 75.39 cde | 4.19 abcd | 11.76 |
| Spencer sdlg | 0.91 bcde | 86.59 bcd | 3.76 bcde | 12.50 |
| Leo | 1.00 bcd | 55.25 defg | 3.41 cdef | 6.25 |
| Guillemet | 1.18 bc | 58.28 def | 3.28 def | 11.76 |
| Spencer clonal | 1.18 bc | 35.71 gh | 2.66 f | 11.76 |
| Duke 7 | 1.65 b | 48.16 efg | 2.81 ef | 17.65 |
| Poly N | 4.12 a | 20.27 g | 0.92 g | 76.47 |

¹ Mean values in each column followed by identical letters are not statistically different according to Waller’s k-ratio t test. There were no statistical differences between blocks for Tree rating and Trunk diameter parameters but there were for Canopy volume.