

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

Continuing Project; Year 8 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 manifold as 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 several new "escape" trees including the Rocky, Keenon, Ballou#1 and the Ballou # 2. These trees appeared to have survived a field epidemic of avocado root rot. We have also imported new avocado varieties for testing which include the Israeli varieties 6, 7, 15, 26, 28, 31, 40, 49, 51, 65, 66, 75, 204, 802, 803, 817, and the Wilg from South Africa.

Breeding Program

We have screened 5180 seeds from the breeding blocks for resistance to *Phytophthora cinnamomi* in 1999. We have retained 66, which showed a high degree of resistance. Most of these varieties had maternal parents D9 and 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 34 seedlings from the breeding blocks, which have shown exceptional resistance to *Phytophthora cinnamomi* after extensive testing. Seven of these are being field tested, three more are being grafted for field tests in 2001. Thirteen more are ready for field-testing and eleven have been grafted to increase budwood in 2000.

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 therefore have implemented 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. Like the first year the second year's results indicate no significant alterations in the flowering times or fruit set due to these treatments. We have decided to continue the girdling program but to discontinue the Uniconazole-P sprays. We covered trees in some of the blocks and used beehives in the spring of 2000 in an attempt to get more crosses between 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. We are also determining the complete parentage of the selected rootstocks from the breeding blocks, which show a high degree of resistance.

The breeding blocks are now made up of G755A, Thomas, G810, G875, G033, 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 256 (West Indian, Israel), Guillemet (PP15, breeding block maternal parent Thomas), Mckee (PP19, breeding block, maternal parent UC 2001) and Thomas, indicated that all three tested rootstocks were as resistant to *Phytophthora cinnamomi* as was Thomas. VC 256 built up higher populations of *P. cinnamomi* in the rhizosphere than did the Guillemet or the Mckee. Very low numbers of *P. cinnamomi* zoospores were attracted to the Guillemet, Mckee and Thomas when compared to Topa Topa. Rootstocks selected for intensive testing in 2000 include Afek (PP18, maternal parent Thomas), Erin (PP21, maternal parent D9), Medina (PP22, maternal parent Thomas), Thomas and Borchard. Plants being grafted for intensive studies in 2001 include Martin (PP26, maternal parent D9), Pond (PP29, maternal parent G6), Crowley (PP34, maternal parent UC2001), Thomas and Borchard.

Field Evaluation

We now have 21 field trials testing 39 clonal root rot tolerant rootstocks throughout Southern California. The following are brief summaries on some of the older trials.

In a nine-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), Spencer (Pauma Valley), Queretaro (Mexico), CRI-71 (Costa Rica), Borchard, UCR 2003 (Escondido), Thomas, D9 (irradiated Duke), Duke 7, UC2011 (Duke-Statom). However for the five year average (1995-1999) the rootstocks yielded in the following order from greatest yield to least yield: Duke 7, Merensky II (Dusa-South Africa), UC2003 (Escondido), Borchard, UC2011 (Duke-Statom), D9 (irradiated Duke), Thomas, Queretaro (Mexico), CR 1-71 (Costa Rica). The Merensky II (Dusa-South Africa) will be 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 five-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 four-year-old trial in Camarillo, CA under heavy root rot pressure, trees were rated as follows from the healthiest to the poorest: Merensky III (Evstro-South Africa), Halma Duke, VC 256 (Israel), Thomas, Spencer (Pauma Valley), Gordon (South Africa), UC 2014 (W-14 South Africa), UC 2023 (G755 C seedling), and Borchard. 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 very low this year and so are not reported. Nutrient analysis from this plot indicates no rootstock effect on leaf concentrations of phosphorous, magnesium, sodium, and copper. It appears that Gordon and UC 2014 result in elevated levels of calcium in leaves while Halma Duke has lower levels of calcium. Thomas results in higher levels of potassium in leaves than any other rootstock. VC 256, Thomas, and Gordon result in higher levels of Zn than most other rootstocks. Borchard results in the highest level of iron in the leaves. All leaf nutrients were in the adequate range except for phosphorous and zinc which appear deficient for all rootstocks.

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

A two-year-old trial in Somis, CA under heavy root rot pressure was rated as follows from healthiest to the poorest: Merensky III (Evstro-South Africa), Berg (PP5-maternal parent D9), Zentmyer (PP4-maternal parent Barr Duke), Thomas, G755A (*P. schiedeana* x *P. americana* seedling) and Duke 7. Tree sizes from largest to smallest were: Zentmyer (PP4-maternal parent Barr Duke), Berg (PP5-maternal parent D9), G755A (*P. schiedeana* x *P. americana* seedling), Thomas, Merensky III (Evstro-South Africa), and Duke 7. Zentmyer was growing better than Thomas, but now all rootstocks look good in this plot.

In a three-year-old trial in Escondido, CA, which compares Spencer (Pauma Valley) as a seedling rootstock with Topa Topa, it was found that the Spencer is much healthier and larger than the Topa Topa (Table 1). It appears that Spencer may be a far better seedling rootstock than Topa Topa. However, yield must be taken before final conclusions are made.

A one-year-old trial established in Carpinteria CA on root-rot infested soil froze its first year in the ground. The %-age of trees surviving the freeze were: Zentmyer (PP4-maternal parent Barr Duke), 75%, Merensky II (Dusa- South Africa), 68%, Thomas, 60%, VC 241 (*P. nubigina*, Israel), 55%, VC 207 (Day-Israel), 53%, VC 256 (Israel), 53%, Spencer (Pauma valley) 45%. It appears the West Indian varieties and Spencer may be susceptible to cold damage when they are young.

A two-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), Thomas, Spencer (Pauma Valley). G755A seems to be doing best at this site.

A one-year-old trial established in Carpinteria, CA on root-rot infested soil. It was rated as follows from healthiest to the poorest: Merensky II (Dusa-South Africa), Thomas, Zentmyer (PP4-maternal parent Barr Duke), VC 256 (Israel). Tree sizes from largest to smallest were: Zentmyer (PP4-maternal parent Barr Duke), Merensky II (Dusa-South Africa), VC 256 (Israel), Thomas. All trees are doing well in this trial.

A one-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 one-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), Thomas, Toro Canyon, Duke 7, Merensky III (Evstro-South Africa). Tree sizes from largest to smallest were: Zentmyer (PP4-maternal parent Barr Duke), Duke 7, Toro Canyon, Thomas, Merensky III (Evstro-South Africa). All varieties are doing well in this plot.

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

A one-year-old trial established in Carpinteria, CA on root-rot infested soil. It rated as follows from healthiest to poorest: Merensky I (Latas-South Africa), Zentmyer (PP4-maternal parent Barr Duke), Uzi (PP 14, maternal parent G6), Merensky III (Evstro-South Africa), Merensky II (Dusa-South Africa), Thomas, 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: Thomas, Merensky IV (South Africa), Zentmyer (PP4-maternal parent Barr Duke), Merensky I (Latas-South Africa), Merensky II (Dusa-South Africa), Uzi (PP14-maternal parent G6), Merensky III (Evstro-South Africa), Aguacate de Mico (Mexico), and Poly N (polyploid-UCLA). Only Poly N is performing poorly enough to be removed from further study.

A one-year old trial established in Oceanside, CA on root-rot infested soil. It rated as follows from healthiest to poorest: Mckee (PP19-maternal parent UC2001), Uzi (PP 14-maternal parent G6), G755A (*P. schiedeana* x *P. americana* seedling), Thomas, Aguacate de Mico (Mexico). Tree sizes from largest to smallest were: G755A (*P. schiedeana* x *P. americana* seedling), Mckee (PP19-maternal parent UC2001), Uzi (PP14-maternal parent G6), Thomas, Aguacate de Mico (Mexico). Only Aguacate de Mico is performing poorly enough to be removed from further study.

A one-year-old trial established in Escondido, CA on root-rot infested soil. It rated as follows from healthiest to poorest: Thomas, Leo (Brokaw selection), Merensky III (Evstro-South Africa), Merensky IV (South Africa), Poly N (polyploid UCLA). Tree sizes from largest to smallest were: Thomas, Leo (Brokaw selection), Merensky III (Evstro-South Africa), Merensky IV (South Africa), Poly N (polyploid UCLA). In this study Merensky III, Merensky IV and Poly N were all doing poorly.

Nine new field trials were established in 2000. These field trials included Merensky II (Dusa-South Africa), Merensky I (Latas-South Africa), Merensky III (Evstro-South Africa), Zentmyer (PP4, maternal parent Barr Duke), Guillemet (PP15-maternal parent Thomas or Barr Duke), Mckee (PP19-maternal parent UC 2001), Steddom (PP24-maternal parent Toro Canyon), Berg (PP5-maternal parent D9), Uzi (PP14-maternal parent G6), Medina (PP22-maternal parent G6), Duke parent, Spencer seedling (Pauma

Valley) G775A (*P. scheideana* x *P. americana* seedling), UC 2023 (G755 seedling), VC 256 (Israel West Indian), VC207 (Day-Israel West Indian), Thomas and Parida (Brokaw selection).

Avocado varieties being propagated for 2001 field trials include Merensky II (Dusa, South Africa), Merensky I (Latas, South Africa), Merensky IV (W14, South Africa), 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), Afeck (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), UC 2076 (Aguacate de Mico, Guatemala), Thomas and Parida (Brokaw selection).

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. It appears that Spencer used as a seedling rootstock may be better than commonly used seedling rootstocks such as Topa Topa. We believe Merensky II (Dusa-South Africa) is ready to release to growers. It yields well in tests here in California and in South Africa. Yield data must be gathered on the other 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. Growth and appearance of Hass avocado as influenced by mulch and seedling rootstocks in a *Phytophthora cinnamomi*-infested field near Escondido, CA, May 20001.

Treatment	Canopy volume (cu ft)	Trunk diameter (mm)	Tree rating (0-5; 5=dead)
Spencer control	70.42 b	43.61 a	1.73 bc
Topa Topa + 1/3 cu yd mulch	30.16 c	27.47 b	3.43 a
Spencer + 1 cu yd mulch	111.25 ab	46.29 a	2.29 b
Spencer + 1/3 cu yd mulch	128.41 a	55.33 a	1.00 c
Spencer + 1/3 cu yd compost	116.66 a	48.21 a	1.50 bc

¹Mean values in each column followed by identical letters are not statistically different according to Waller's k-ratio t test.