



**SELECTION OF AVOCADO (*Persea americana*) ROOTSTOCKS
TOLERANT/RESISTANT TO *P. cinnamomi***

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Zentmyer screened and evaluated new rootstocks

1959–1960

Avocado cuttings and seedlings growing in temperature controlled tanks containing nutrient solution, for root rot resistance tests.



1960–1961

Dr. George A. Zentmyer. University of California, Riverside. Examined aquacatillo seedlings and tested them in Citrus Experiment Station Researchers for use in California.

INTRODUCTION

Selected in California, U.S.A. Thomas and Duke 7 rootstocks are considered resistant to this disease.

Duke 7 rootstock has turned out to be the **most common** rootstock in the avocado industry because it produces healthy, uniform and productive trees.

The selection of a resistant rootstock to root rot by *P. cinnamomi* has been partially done as this selection must be a priority to control the disease.

Why is the avocado known as Green Gold in Mexico ?



Avocado is planted in **112 000 782 ha** in **28** states of Mexico.

- Mexico is both the largest producer of avocados in the world and the largest exporter, far above all other countries.

Table 1. Approximate annual production of avocado (tons/year)

Mexico	1, 000, 000
Chile	220, 000
USA	180, 000
Peru	100, 000
South Africa	80, 000

In Mexico

Why is the importance?

1999

- In the municipalities of Uruapan, Michoacán, Mexico
550 000 trees were found with incidence of *P. cinnamomi*.

The search and identification of rootstocks tolerant/resistant is a priority against root rot and trunk canker caused by *P. cinnamomi*.

OBJECTIVE

The objective of this work was to identify and generate new avocado rootstocks tolerant/resistant to *P. cinnamomi*.

I. MATERIALS AND METHODS

1. Isolation of pathogen
2. Avocado germoplasm

1. Isolation of *P. cinnamomi*

A. Selective medium PARPH (on V8 juice agar medium).

Pimaricin

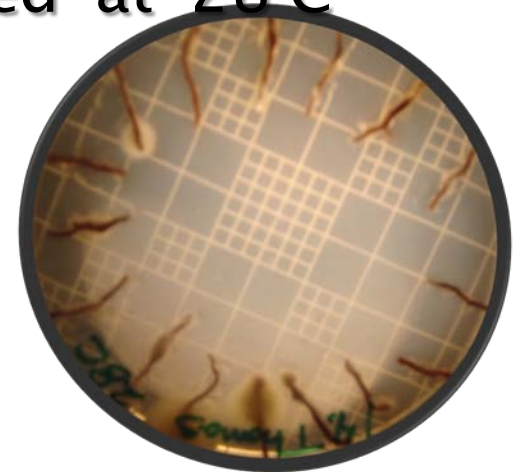
Ampicillin

Rifampicin

PCNB

Hymexazol

B. Root infected sections were incubated at 28°C during 4 days.



1. Isolation of *P. cinnamomi*

C. This inoculum was increased in V8 juice liquid medium.



D. Development of *P. cinnamomi* in V8 juice liquid medium.



2. Avocado germoplasm for screening

Table 2. Seedborne plants of the avocado (*Persea americana*) screened for incidence of root rot caused by *P. cinnamomi*.

Screened total	
Avocado germoplasm	Seeds number
Duke	12
Thomas	51
Colín	74
Tepetl	60
Tolimán	60
Atlixco	342
Tepeyanco	358

for root rot resistance tests

Evaluation of tolerance/resistance was done by 2 methods

Method 1

Under controlled temperatures of 17 and 28°C and room temperature (greenhouse at 18.6°C)

- 250 mL of mycelial suspension of *P. cinnamomi* were inoculated in soil ($10^4/\text{mL}$).

Method 2

Seedlings of 5 cm and 15-20 cm high were inoculated They grew (in greenhouse at 18.6°C)

- These seedlings were inoculated with 200 mL mycelial suspension in soil ($10^4/\text{mL}$).

For inoculation

Four holes, 3 cm in depth each, were made in the soil near the root. Inoculum was deposited in these holes.

- After inoculation, the soil was irrigated to saturation.

RESULTS

AND

DISCUSSION

Morphological characteristics

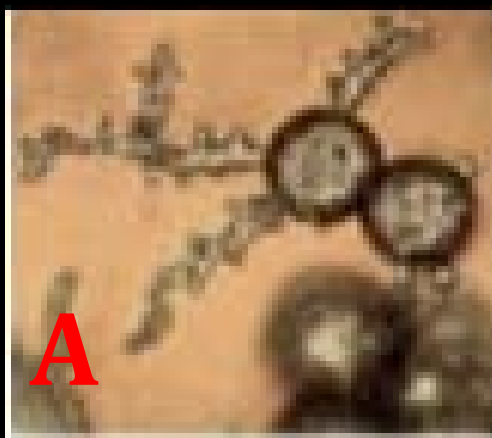
A. Chlamyospore germination,

B. sporangia

C. hyphal swellings of *P. cinnamomi*.

Molecular identification of *P. cinnamomi*.

Accession number for Genebank is in progress.



**EFFECT OF TEMPERATURE
IN THE SELECTION**

THOMAS

A

18.6 °C

Dead root

TEPEYANCO

B

18.6 °C

Healthy roots and with symptoms

TEPETL

C

17 °C

Plants with symptoms and dead

28 °C

17 °C

TEPEYANCO

Non inoculated
Without symptoms

28 °C

ATLIXCO

28 °C

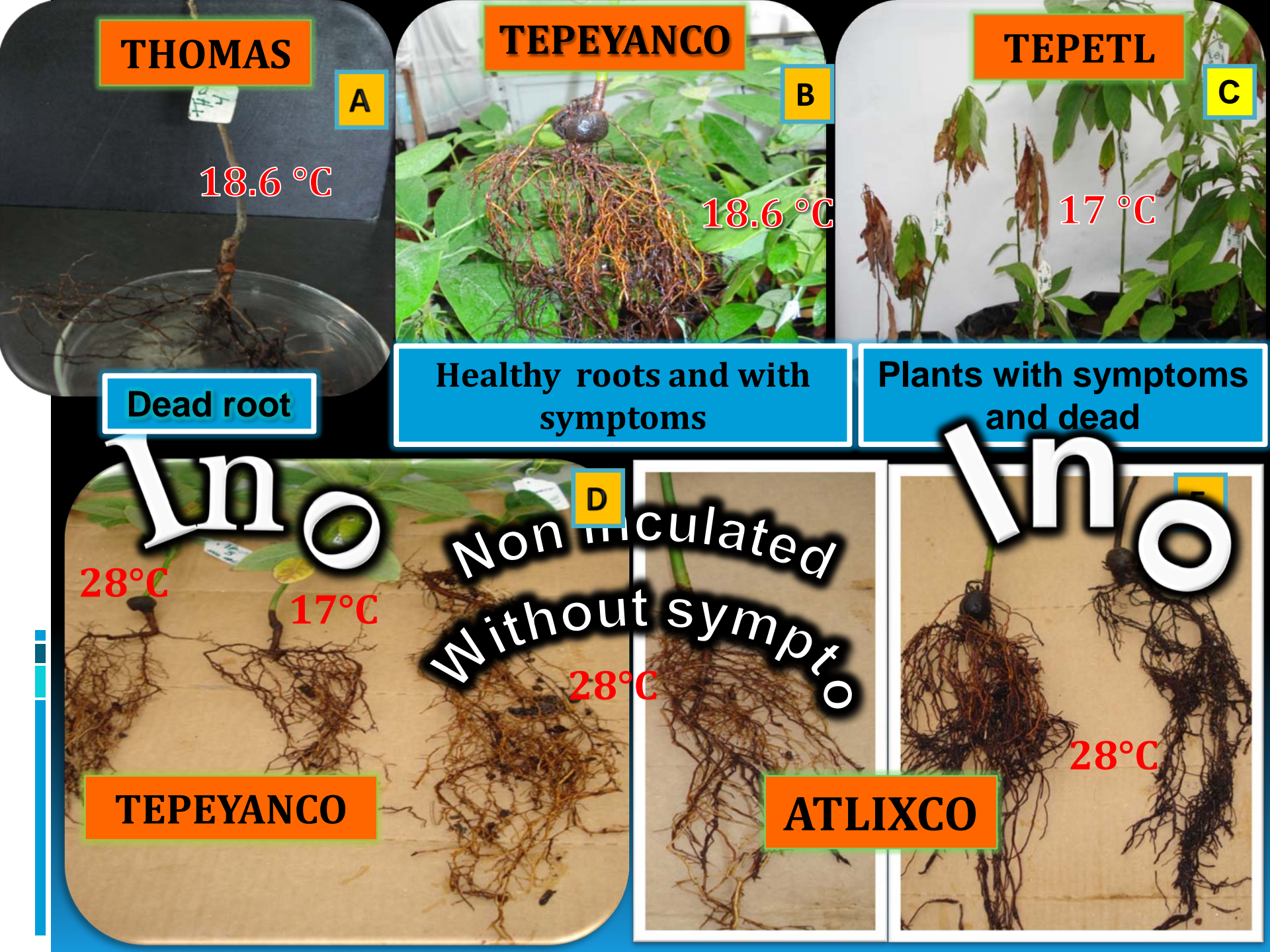


Table 3. Percent for mortality and infection caused by *P. cinnamomi* under controlled temperatures in selection of resistance/tolerance of rootstock.

Cultivars		% of mortality and infection								
		Mortality			Wilting symptoms			Without symptoms		
		28°C	17°C	18.6†°C	28°C	17°C	†18.6°C	28°C	17°C	†18.6°C
Thomas	Inoculated	28.57 ^{bcd}	14.29 ^{cd}	14.29 ^{cd}	42.8 ^{ab}	57.1 ^{ab}	42.8 ^{abc}	28.61 ^f	28.6 ^f	42.9 ^d
	Non inoculated	0 ^e	0 ^e	0	0	0	0	100 ^a	100 ^a	100 ^a
Duke-7	Inoculated	75 ^a	50 ^{abc}	50 ^{abc}	-	50 ^{ab}	-	25 ^h	50 ^k	50 ^d
	Non inoculated	0 ^e	0 ^e	0	0	0	0	100 ^a	100 ^a	100 ^a
Tepetl	Inoculated	20 ^{cd}	40 ^{abcd}	60 ^{ab}	60 ^a	20 ^{abc}	30 ^{abc}	20 ⁱ	40 ^e	10 ^j
	Non inoculated	0	0	0	0	0	0 ^c	100 ^a	100 ^a	100 ^a
Atlixco	Inoculated	0	0	10 ^d	10 ^c	0 ^c	20 ^{abc}	90 ^b	100 ^a	70 ^c
	Non inoculated	0	0	0	0	0	0	100 ^a	100 ^a	100 ^a
Tepeyanco	Inoculated	0	0	0	10 ^c	0 ^c	10 ^c	90 ^b	100 ^a	90 ^b
	Non inoculated	0	0	0	0	0	0	100 ^a	100 ^a	100 ^a

†: Greenhouse room temperature.

Means with same letter per column do not differ significantly, Tukey (Pr ≥ 0.05).

The above results indicate:

- Atlixco and Tepeyanco cultivars are tolerant to *Phytophthora cinnamomi* infection at 28°C.
- These cultivars **showed from 0-20%** infection and a high percentage of plants **without symptoms**.

Table 4. Selection of 5 cm high seedlings inoculated with *P. cinnamomi* (18.6°C).

Cultivars		% mortality and infection			
		Mortality	Wilting symptoms	Stem canker	Without symptoms
Thomas	Inoculated	100^a	-	-	-
	Non inoculated	0	0	0	100 ^a
Tepetl	Inoculated	100^a	-	-	-
	Non inoculated	0	0	0	100 ^a
Toliman	Inoculated	100^a	-	-	-
	Non inoculated	0	0	0	100 ^a
Colín	Inoculated	43.47 ^b	47.82 ^a	0	8.7 ^d
	Non inoculated	0	0 ^b	0	100 ^a
Atlixco	Inoculated	36.66^b	25.55^{ab}	8.89^a	28.9^b
	Non inoculated	0	0 ^b	0	100 ^a
Tepeyanco	Inoculated	36.66^b	33.33^a	10^a	20^c
	Non inoculated	0	0	0	100 ^a

Means with same letter per column do not differ significantly, Tukey (Pr \geq 0.05).

In selection of 5 cm high seedlings

- **Percentage mortality** in Thomas, Tepetl and Toliman was 100%, 30 days after inoculation.
- **The lowest mortality was found** in Atlixco and Tepeyanco (36.66 and 36.66 %).

These also showed **wilting symptoms**
(whit 25.5 and 33.3 %, respectively)

In selection of 5 cm high seedlings inoculated

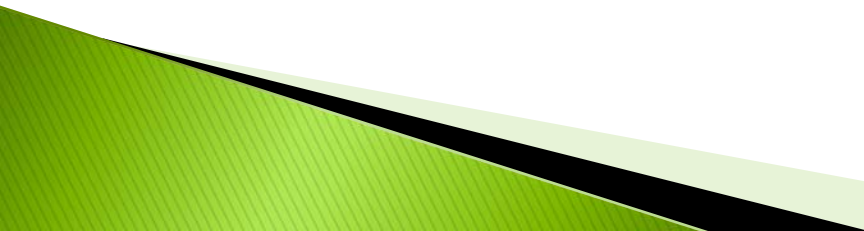
- The stem canker symptoms were only present in low percentages in Atlixco and Tepeyanco.
(of 8.7 and 10%)**
 - The results are consistent in Tepeyanco and Atlixco, with 20 and 28.9% of seedlings without symptoms indicating a higher tolerance to infection.**
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Table 5. Formation of new shoots and roots after inoculation of *P. cinnamomi* at 5 cm high seedlings (18.6°C)

Cultivars		% of new seedling shoots		
		Mortality	With Symptoms	Without symptoms
Tepetl	Inoculated	20^a	-	-
	Non inoculated	0	0	100 ^a
Colín	Inoculated	17.39^a	4.34^a	8.7 ^c
	Non inoculated	0	0	100 ^a
Tepeyanco	Inoculated	7.77^b	3.33^a	5.6^d
	Non inoculated	0	0	100 ^a
Atlixco	Inoculated	6.66^b	4.44^a	8.9^b
	Non inoculated	0	0	100 ^a

Means with same letter per column do not differ significantly, Tukey (Pr ≥ 0.05).

In selection of seedlings inoculated at 5 cm high

- In seedlings of Tepetl, Colín, Tepeyanco and Atlixco from 10 to 15 days after inoculation and death of the first seedling, there was development of one or two new seedling shoots. **These, were reinoculated for prevent escape of the infection.**


- Tepetl and Colín showed **the highest mortalities**
(20 and 17.4%, respectively)
 - Atlixco and Tepeyanco showed **the lowest mortalities**
(6.66 and 7.77%, respectively)
 - **Forty days** after inoculation, the second seedling shoots showed **few necrotic small spots**.
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Figure 3. New stem shoots and roots emerged 10 and 15 days after the first inoculation at 5 cm high seedlings.

- The mechanisms of resistance of the avocado seedling to the infection of *P. cinnamomi* are unknown.

**SELECTION IN INOCULATED
OF 15-20 cm HIGH SEEDLINGS**

Table 6. Mortality and infection of seedling inoculated with *P. cinnamomi* at 15 to 20 cm high at room temperature (18.6 °C).

Cultivars		% of mortality and infection			
		Mortality	Wilting symptoms	Stem canker	Without symptoms
Thomas	Inoculated	0 ^c	64.28^a	10 ^a	30 ^{cd}
	Non inoculated	0	0	0	100 ^a
Tepetl	Inoculated	90^a	10 ^b	0 ^b	-
	Non inoculated	0	0	0	100 ^a
Toliman	Inoculated	90^a	10 ^b	0 ^b	-
	Non inoculated	0	0	0	100 ^a
Colín	Inoculated	17.9 ^b	64.28^a	7.14^{ab}	10.71^{de}
	Non inoculated	0	0	0	100 ^a
Tepeyanco	Inoculated	8^{bc}	16.21^b	8.78^{ab}	66.89^b
	Non inoculated	0	0	0	100 ^a
Atlixco	Inoculated	6.18^{bc}	16.66^b	28.78^a	47.72^{bc}
	Non inoculated	0	0	0	100 ^a

Means with same letter per column do not differ significantly, Tukey (Pr ≥ 0.05).

Inoculating at 15-20 cm high seedlings

- Tepetl and Toliman showed a **high mortality** (90%)
- The **lowest mortality** were obtained in Atlixco and Tepeyanco (with 6.18 and 8%)
- Thomas was resistant to the inoculation in seedlings showing 0% of mortality. However, Thomas and Colín **showed high wilting** (64.28%).

Inoculating at 15-20 cm high seedlings

- The percentage of seedlings with symptoms of stem canker, Atlixco showed the highest value (28.78%).
- Tepeyanco and Atlixco obtained the highest percentage of seedlings without symptoms.



Figure 4. A) Symptoms of the stem canker caused by *P. cinnamomi*, B,C) Damage with dark spots and exudation.

Selection in inoculated seedlings of 15-20 cm high

- 25 days after inoculation seedlings showed 1 cm necrotic spots.
- At 90 days, necrosis reached 20 cm in length, plants showing wilting and finally died.

CONCLUSIONS

- Adequate temperatures for selection of rootstocks tolerant/resistant to *P. cinnamomi* are 18.6 and 28 °C (82 °F).
- When seedlings of 5 cm and at 15-20 cm high are inoculated, Atlixco and Tepeyanco are the most promising tolerant/resistant rootstocks to *P. cinnamomi*.

Thanks

Thanks

