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Hiking shoes infested





Incidence of *P. ramorum* Isolated From Rivers And Streams In Santa Cruz County, CA. 2001-02

Sample Source	04/09/01	09/18/01	01/04/02	01/31/02	02/08/02	02/19/02	02/28/02	03/10/02	03/19/02	03/25/02	Total
Bean Creek	+		+		+		+	+	+	+	7
Soquel Creek						+		+		+	3
Lompico Creek					+	+		+			3
Aptos Creek											0
San Lorenzo River		+				+	+	+	+	+	6
Branciforte Creek			+	+	+	+					4
Corralitos Creek											0
Total	1	1	2	1	2	4	2	5	2	3	23

Phytophthora ramorum Discovered in a California Nursery



December, 2000

Again, March, 2002

Aerial dispersal

FRANK





Dispersal within Plant Block 2004-2005 Season 1/24/2005





Central Inoculated plant 10 inoculated leaves



Number of infected leaves in all 5 replicated blocks

Susceptibility of Azaleas

Azalea or Rhododendron	% w/ symptoms	% isolaton success
Hino-Crimson	87.5	57.1
Albert and Elizabeth	87.5	42.9
Formosa	62.5	100.0
Okusatsuki	87.5	71.4
Irish Lace	100	87.5
Prize	62.5	100.0
Remembrance	37.5	0.0
Northern HiLights	87.5	57.1
Cunningham's White	100	87.5
Gardener's	75	16.7
Purity	25	100.0
Twenty Grand	75	83.3
Ben Morrison	75	66.7
Blue Danube	75	83.3
Cherry Ripe	75	83.3
Madonna	62.5	100.0
Gwenda	25	100.0

Zoospore inoculation, detached leaves, mist chamber incubation

Evaluation of APHIS Protocol for Detection Success and Laboratory Method

# Samples	Method	Detection Success St. dev.
302	ELISA	100 %
193	PCR Nested	100 %
180	PCR Real Time	100 %
296	PARP (State Lab)	73.9 % (39.3)
218	PARP (Local)	70.0 % (37.4)

Four Seasons, up to 6 months after inoculation Rhododendron and Camellia

Camellia Flower Bud Blight



Fungicides for P. ramorum

Rhododendron, Camellia, Pieris, and Viburnum

Pre-infection (preventative) fungicide application

- Foliar application
 - mefenoxam (Subdue Maxx, Syngenta)
 - dimethomorph (Stature DM, BASF)
 - pyraclostrobin (Insignia, BASF)
 - fenamidone (Fenstar, Olympic)
 - cyazofamind (Segway; FMC, turf only)
- Preventative control for at least 4 weeks, except for rhododendron, which was at least 2 weeks but less than 4 weeks after fungicide application
- When lesions developed, the pathogen was successfully recovered from those lesions. Only dimethomorph and cyazofamid reduced recovery success rate.

Post-infection (curative) fungicide application

- No reduction in lesion growth
- High rate of recovery of pathogen with all fungicides. For rhododendron, the pathogen could be recovered reliably for at least 6 weeks after fungicide application from intact and fallen leaves.
- Re-isolations from leaves treated with dimethomorph and cyazofamid were weak in culture

Seasonal stream concentration of P. ramorum in Santa Cruz Co.

P. ramorum concentration = $e^{4.8 + 0.049Rain - 0.15 \max Temp}$

Rain = mm (4 day prior to sampling) *max Temp* = °C (65 day prior)

2.5 Detected Infective Spores (Actual) × Not Detected Infective Spores ("Fitted") 2 Infective propagules / pear / liter 1.5 0.5 (mmmm) 0 ന January April October April July April April July October July October January July October January January 2004 2005 2006 2007

Irrigation with Stream and City Water

2004-2007 (4 annual experiments)

Experimental treatments

- 1. City Water/ Drip
- 2. City Water/ Sprinkler
- 3. Stream Water/ Drip
- 4. Stream Water / Sprinkler

Disease detected only 3 times on plants sprinkler irrigated with stream water:

22 Apr 2005 12 May 2006 23 Jun 2006





of necrotic lesions on multiple plants



Recovery of P. ramorum from buried infested leaf disks in soilfield and greenhouse





Infected leaf disks were buried below the soil surface and retrieved

Production of chlamydospores and sporangia



Leaf disks removed from field soil Placed in Petri plates and flooded with deionized water, incubated 7 days at 20 C.



Root Infection Experiment 3 (2006-07)

20 weeks- no P. ramorum in roots
30 weeks- no P. ramorum in roots
40 weeks- P. ramorum in roots from Field
60 weeks- P. ramorum in roots from Greenhouse





Leaf Wetness





Sensors in field measured leaf wetness hours

When does sporulation occur?



Importance of Rainfall and Sprinkler Irrigation in Supporting Sporulation and Spread in Water Runoff 2006-2008

- Rainfall is most effective in producing conditions for foliar sporulation and inoculum in runoff.
- Sprinkler irrigation can also be effective.
- Leaf wetness hours affects the concentration of inoculum during event.
- Foliar disease can result from runoff water.
- Root disease can result from runoff.



Environmental Factors for Sporulation (2008- 2010)







Experimental Methods

Seasonal Inoculation Summer, fall, winter, spring Two years: summer 2008 - summer 2010 Rhododendron , Camellia, CA Bay Felton, California

Leaf Wetness Treatments

- 1. Natural, no additional wetness added
- 2. Misting: Wet night only (LW > 95%)
- 3. Misting : Wet continuously (LW >95%)

Inoculum on Leaves Evaluated <E> Leaves "washed" after wetness treatments. Wash is filtered and propagules counted (CFU/L)



Statistical model to explain sporulation (an example)

CFU/L/leaf = treat123 + week lesion age + a*log(hrs_wet) + b*max temp + c*rel. humidity + d*lesion_size + random effects(due to year, season and block effects)

Factor	AICC Comparison Sta	<u>atistic</u>
Full model	16148	
No max temp	16158	
No lesion size	16358	
No leaf wet hrs	16730	Factor has increasing
No lesion age	17045	importance to model
No rel. humidity	18180	
No treat 1,2,3	19216	

Publications available at

http://ucanr.org/steve_sod

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CANGC: California Association of Nurseries and Garden Centers