Diagnosis of *Phytophthora ramorum* in Trees

by Dr. Kim D. Coder, Warnell School of Forest Resources, University of Georgia April, 2004

The organism shown to be responsible for SOD (sudden oak death) is ***Phytophthora ramorum***, a fungus / yeast-like brown algae. This pathogen generates a number of symptoms in the trees infected. Of the trees and large shrubs shown to be infectable with this pathogen, some species have more serious stem and branch lesions like oaks, while other species have primarily leaf and twig lesions. In a single landscape, multiple hosts can keep the pathogen present for further attacks.

This publication was prepared by reviewing approximately 35 research or disease announcement publications in Europe and North America. In addition, a number of factsheets and synthesized information guides were reviewed for continuity. This publication is designed for field diagnosis of SOD-like symptoms and related symptom sets on community trees. This publication should not be used in tree nursery situations, and is not a pathogen centered review. It is critical to seek pathological expertise and testing for confirming disease organism presence. A selected bibliography is available entitled "Sudden Oak Death – SOD: Bibliography of Important Literature." (Coder, Kim D. 2004. University of Georgia, Warnell School of Forest Resources outreach publication SFR04-1. 2pp.).

Names

The tree syndrome or symptom set which characterizes attack by ***Phytophthora ramorum*** has common names of "ramorum dieback," "ramorum blight," "ramorum twig blight,""ramorum leaf blight," "ramorum stem canker," "blood spot disease," or "sudden oak death" (SOD). ***Phytophthora ramorum***, and the less virulent ***Phytophthora nemorosa*** and ***Phytophthora pseudosyringae*** are all relatively new pathogen species recovered from trees which show ramorum blight symptoms.

Trees At Risks

Azalea, rhododendron, viburnum, camellia, and mountain laurel are at risk for leaf and twig attack. The red oak group is at risk of stem and branch cankers leading to death. Table 1 provides a species list of infectable trees and large shrubs listed in the literature. Table 1 does not represent a comprehensive list of all species or cultivars susceptible to ramorum blight. Table 2 provides a list of geographic locations where the pathogen has been identified in the field on trees.

Symptoms on Trees

Phytophthora ramorum causes the following tree responses:

The University of Georgia

UNIVERSITY OF GEORGIA
WARNELL SCHOOL OF FOREST RESOURCES
OUTREACH PUBLICATION SFR04-3

Leaves – Symptom description includes leaf wilting, discolored leaves, leaf browning, leaf blight, terminal and marginal leaf lesions, petiole and leaf base necrosis, and leaf loss. Leaves develop large (>1/5 inch in diameter) necrotic lesions. Infection spots can be surrounded by a thin yellow halo on the leaf blade. The brown to black leaves have water-soaked lesions with diffuse borders expanding into large blotches finally resulting in leaf death. Petioles develop necrotic, blackened lesions. Leaf blade infections initiate marginal and terminal dead areas, while twig infections initiate petiole and leaf base death. Eventually leaves and shoots wilt as a prelude to rapid decline and death. Leaf loss tends to occur on the outer six inches of twigs around the outside of the crown. As tree defenses fail, stomates become locked open by pathogen produced growth regulators.

Twigs -- Symptom decription includes twig cankers, twig lesions, twig dieback, and twig blight. Twigs showing cankers are usually less than 1/4 inch in diameter. Dieback throughout the crown begins with twig loss in the outer edge of the crown.

Branches -- Symptom description includes branch dieback and crown dieback. Infected branches develop dark brown to black discolorations followed by a dying back from the tip downward. Cankers on small branches less than 3/4 inch in diameter cause death of the branch tissues beyond the canker. Larger branches with multiple cankers are girdled, with tissues beyond the cankers dying.

Shoots -- Symptom description includes new shoot wilting, shoot drooping, shepard's crook, and shoot dieback. As shoots react to the pathogen, dormant and adventitious buds can be released which soon wilt and die.

Stem -- Symptom description includes development of stem lesions, stem bark lesions, stem base discoloration, and discolored vascular tissue. The stem develops areas of dark brown to black discolored bark. The brown discoloration continues into the cortical area and phloem beneath the bark. Xylem discoloration is more limited and darker. Stems ooze a dark red, amber, or black colored, thick liquid from wet spots concentrated in the lower ten feet of the stem. The wet oozing sites on the stem can occur up to 60 feet above the ground. The liquid expressed has a deep oak tannin smell, not urine or beer-like as with bacteria or yeast infections.

Oozing sites, and surrounding stem areas, are colonized by bark beetles and ambrosia beetles. In one study, beetles were found in every oozing tree. These green foliaged trees all died within the first year. Stem cankers develop around oozing spots and are outlined within the inner bark by thin black lines. Stem cankers can grow to be six feet long. Stem and branch cankers usually develop before foliage symptoms are visible.

Roots -- Symptom description includes tree root collar lesions and root collar decay. Trees do not develop lesions on primary roots but around the root collar area and higher aerial portions of the tree. Lesions do not stretch below the ground line.

Trees – It is estimated 10% of California's tanoak / redwood forest is infected. In the most susceptible trees, the time between first noticeable dieback and death is three to eight weeks in the growing season. Many susceptible trees will take several years to die. In one study in a forest setting, approximately 25% of trees had symptoms with an annual mortality of 10%. Dead forest spots were approximately 800 feet in diameter and composed of up to 40 trees. As trees become more stressed, other pathogens like ***Hypoxylon*** and ***Armillaria*** attack.

Sites & Environments – The pathogen has a selective advantage over tree defenses near temperatures of 65-75^{o}F. Below 55^{o}F lesion growth is slow. Above 98^{o}F the pathogen is damaged. Moderate to high humidity helps facilitate attack. Trees are most susceptible where root growth is constrained by compaction, poor drainage, mechanical injury, heavy turf competition, and over-watering. Elevated nitrogen levels can initiate poor defensive reactions in tree tissues. Soil pH levels above 5.0 decreased tree defensive effectiveness, accelerating as pH climbed. Calcium and magnesium (lime

or dolomitic lime) interfered with tree defenses. Prolonged drought lessened the trees's ability to defend itself effectively during any following wet period. Bottomland sites, low places in the landscape, and sites where water can not effectively drain away from the rooting area are locations where trees are less effective in defense. Poor soil aeration from various causes also minimize defense. Stem cankers are derived from foliage infections or soil borne by wind, rains splash or by animals. Note this pathogen can be moved through the air. The pathogen is found in soil but does not attack roots. Trees near forest edges (within 20 feet), surrounded by species susceptible to leaf infections, and on sites where strong wet / dry fluctuations occur in soil moisture are most at risk of severe damage.

Oak Confusion

There are several pathogenic interactions with oak (***Quercus*** spp.) which can be confused with each other. It is important to differentiate the various symptom sets and correctly identify the various pathogens for proper and effective treatment. Below are listed the responsible pathogens and the named oak reaction.

Phytophthora ramorum – SOD / ramorum blight
Phytophthora cinnamomi -- Southeastern "ink" disease (similar in symptoms to SOD except for much less mortality and hot temperature optimum (~90°F))
Phytophthora cinnamomi & ***Armillaria mellea*** – North American oak decline
Phytophthora spp. complex – European oak decline
Ceratocystis fagacearum – oak wilt

Take A Sample

Send tree samples to the state university pathology laboratory for pathogen identification within 24 hours of sampling. Sample should be the inner bark and cambium area of living, but infected tree tissue. Disinfect all tools before and after sampling with at least 70% alcohol in a bottle or spray. Chlorine solutions (10%) are also effective. Allow tools to dry then use a match or lighter to run a flame across the cutting surface.

Shave outer bark off of stem within four inches above or beside an oozing spot, shaving inward to the wood and toward the spot. When a thin dark defensive line is evident between the infected and non-infected tree tissues, remove the inner bark tissue (living cortex and phloem) down to the wood on both sides of the defensive line. Remove tissue with a knife or hatchet to produce a large sample at least two square inches in area. The later into the Summer and the hotter the daily temperatures, the more difficult will be isolating the pathogen. Put the sample immediately into a paper bag, not plastic, and seal. Record date, tree species and specific location. Transport immediately, assuring the sample remains cool. Be sure to maintain good sanitation practices in sampling and movement around the site.

Treatments

At the current time containment of the pathogen is the primary management activity. Quarantines have been placed on nurseries, nursery stock and soil movement (including vehicles and foot traffic). Forest harvesting should be stopped in or near infected areas. The pathogen can be found in soil, in water washed from infected areas, and in plant tissues on the ground. An eradication in a forest and community setting around an infected nursery is currently under testing for effect. Potentially, other ***Phytophthora*** controlling pesticides may be effective and their use is under study.

Table 1: List of tree and large shrub species infectable by ***Phytophthora ramorum*** as listed in the scientific and government literature. The severity of damage is listed by the number of asterisks ranging from none (unknown severity) to **** (extremely poor defenses and severe damage).

scientific name – common name	**scientific name – common name**
Abies grandis – grand fir *	Quercus cerris – Turkey oak **
Acer macrophyllum – bigleaf maple *	Quercus chrysolepis – canyon live oak ***
Aesculus californica – California buckeye **	Quercus falcata – Southern red oak **
Aesculus hippocastanum – horsechestnut *	Quercus ilex – Holm oak **
Arbutus spp. – madrones ***	Quercus kelloggii – California black oak ***
Arbutus menziesii – Pacific madrone ***	Quercus palustris – pin oak **
Arctostaphylos manzanita – manzanita **	Quercus parvula (Quercus wislizenii) – interior live oak **
Azalea japonica (Rhododendron molle sub japonicum) **	Quercus parvula var. shrevei – Shreve oak ***
Calluna vulgaris – heather *	Quercus petraea – sessile oak *
Camellia spp. **	Quercus robur – English oak *
Camellia japonica **	Quercus rubra – Northern red oak **
Camellia sasanqua **	Rhamnus californica – California coffeberry *
Castanea sativa – sweet chestnut *	Rhamnus purshiana – cascara buckthorn **
Chamaecyparis lawsoniana – Lawson cypress *	Rhododendron spp. **
Corylus cornuta var. californica – California hazelnut *	Rhododendron catawbiense **
Fagus sylvatica – European beech *	Rhododendron macrophyllum – California rhododendron **
Hamamelis sp. – witch-hazel *	Rhododendron occidentale – azalea **
Heteromeles arbutifolia – toyon **	Rhododendron yakushimanum **
Kalmia spp. – laurels **	Rubus spectabilis – salmonberry **
Kalmia angustifolia – laurel **	Sequoia sempervirens – Coast redwood **
Kalmia latifolia – mountain laurel **	Syringa spp. – lilacs *
Leocothoe sp. *	Taxus spp. – yew *
Lithocarpus densiflorus – tanoak (Lithocarpus densiflora) ****	Toxicodendron diversolobum – poison oak *
Lonicera hispidula – California honeysuckle *	Umbellularia californica – California bay-laurel *
Picea sitchensis – sitka spruce *	Vaccinium spp. **
Pieris spp. **	Vaccinium myrtillus – biberry **
Pieris formosa var. forrestii **	Vaccinium ovatum – huckleberry **
Pieris japonica **	Vaccinium vitisidaea – cowberry **
Pittosporum undulatum – Victoria box *	Viburnum spp. *
Pseudotsuga menziesii – Douglas-fir **	Viburnum X bodnantense – arrowwood *
Quercus spp. **	Viburnum fragans *
Quercus agrifolia – coast live oak ***	Viburnum plicatum *
	Viburnum tinus **

Table 2: General field locations of confirmed findings of ***Phytophthora ramorum*** and the specific mating type, if known.

North America
- USA
  - California (A2)
  - Oregon (A1 & A2)
  - Washington
- Canada (A1 & A2)
  - British Columbia

Europe (A1 & A2)
- Belgium (A2)
- Denmark
- France
- Germany
- Ireland
- Italy
- Netherlands
- Norway
- Poland
- Slovenia
- Spain
- Sweden
- United Kingdom (A1)