DESCRIPTION:	**Studies in the Biology and Control Oak Root Fungus**
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Project Report 2001

STUDIES IN THE BIOLOGY AND CONTROL OF OAK ROOT FUNGUS

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Summary

Armillaria root disease is an important disease of pears that is apparently increasing in prevalence. Over the past four years we have conducted a number of studies into the basic biology of the pathogen. Our data ~~has~~ supports several conclusions: 1) Much of the increase in Armillaria root disease in pears is due to changes in cultural practices, most likely irrigation, rather than changes in pathogen populations; 2) Spread of the pathogen is primarily by growth of rhizomorphs through the soil, with root to root contact being a minor form of spread; 3) Rhizomorphs rarely extend greater than 30 cm into the soil; 4) Initial infection is as likely to take place at the root collar as on peripheral parts of the root system; and 5) Pear trees appear to tolerate infections on peripheral parts of the root system, but decline quickly when infection reaches the root collar.

Progress to Date:

Evaluation preplant and postplant treatments chemical controls

We are currently testing both preplant and postplant treatments in Lake County utilizing several different fungicides. Following the initial treatments the orchards are monitored each year for symptoms associated with Armillaria root disease. Because of the nature of this disease we do not expect to see dramatic results each year. However, it is important to continue to observe these trials. Postplant trials are intended to test the possibility of prophylactic protection against infections by rhizomorphs, now thought to play a large role in infecting pear trees on the North Coast.

We are continuing to monitor a trial in Lake County. Treatments were applied in 1998-2001 according to label instructions to randomly selected replant sites in *Armillaria*-infected pear orchards planted in loam or sandy loam soils in Scotts Valley and Upper Lake. The following treatments have been applied:

1. metam sodium (Vapam®), 2 qts./100 gpa (pre-plant only)
2. SODIUM TETRATHIOCARBONATE (Enzone®), 2.5 gallons /site pre-plant alone or followed by 1 PINT PER 100 GALLONS post-plant each year in nonbearing years)
3. untreated control

The systemic fungicide Propiconazole (marketed under several different trade names, Syngenta Corp.) was dropped as a treatment in 2001 due to a lack of company interest in

registration for pears

Prior to treatment, diseased trees and accompanying soil were removed to a depth of about 6 feet by backhoe. All visible roots to about ½" diameter were removed by hand from the hole and surrounding soil. The hole was then refilled and material applied by hand from a spray tank. Applications were timed to ensure uniform volume at each site.

Growth was measured in April 1998, November 1999, and November 2000 utilizing calipers at 10 cm above the graft union. Differences between treatments were not significant. Several trees in the treatments and controls have died in the first year, although not from *Armillaria* (Table 1).

Table 1. **Oak Root Fungus Control Project , 1998 to 2001 - summary of tree deaths at Ivicevich Orchard Scotts Valley, Lake County.**

	Year of Tree Death			Total
Treatment	**1999**	**2000**	**2001**	**Tree Deaths**
Vapam	K-14	G-6		**2**
Pre + post Enzone			G-7	
			N-11	**2**
Pre Enzone			H-5	
			H-6	**2**
Control			J-11	
			K-12	
		V-9		**3**

Control of Armillaria with mustard

We have established a field trial in Lake County to determine the efficacy of mustard in controlling the spread and impact of *Armillaria* in a commercial orchard. A replicated experiment of paired treatments (four pairs) was planted in fall 2000. The total experiment covers approximately 8 acres. Seed (10 lbs./acre) was broadcast in row middles, leaving tree rows bare as much as possible. Selections of Cutlass Indian mustard was utilized. *Armillaria* infection presence and severity at the site has been previously mapped at this site. In addition, individual genotypes of the pathogen have also been mapped. Because of this we have true replication of the treatment; i.e., the same genotype of the pathogen is receiving different treatments. Changes in pathogen distribution and tree condition will be monitored over the next several years.

Establishment of mustard was excellent in 2001. However, treatment by the grower of the plants with herbicides reduced the biomass of mustard between the rows (i.e., directly under the trees). Based on past studies, this is the most likely area where *Armillaria* inoculum is found. However, the large size of the mustard plants often blocks the sprinkler systems. Therefore, we must continue to evaluate the trade-offs between the use of mustard to reduce the efficacy of *Armillaria* inoculum and standard grower practices.

Control of Armillaria by root crown excavation

In 1998, the root systems of 21 mature pear trees were excavated at a Lake County orchard. The trees were located within and on the edge of known *Armillaria* infection centers. This work was originally done in conjunction with monitoring the infection center for water stress. Root systems were excavated using super sonic air excavation system. Soils were removed from around the trees by an air jet flowing at 330 cfm at 100psi. The root systems were excavated to a minimum diameter of 2 meters and a minimum depth of 1 meter. Following soil removal, root systems were individually dissected using hand tools. Using this method, we were able to visualize the root systems of the trees as they would naturally appear. As with our previous excavations, there was a general lack of root overlap between adjacent trees. No between-tree root contact was detected. There was no consistency in root architecture among the excavated trees; trees had between 4 and 9 major lateral roots. In many instances, large lateral roots made sharp turns when they encountered the more compact soils between the rows of trees. Fibrous roots were found primarily at the peripheral areas of the root systems.

Prior to excavation, tree crowns were visually rated on a scale of 1 to 5 (1, healthy, full crown with good shoot growth; 2, reduced top shoot growth; 3, most shoots with reduced growth; 4, dieback evident, leaves small and lighter in color; 5, dead.) (Table 2). Signs of *Armillaria* were found on 11 of the 21 trees. *Armillaria* was mostly found in the form of discrete lesions scattered on root surfaces. These lesions ranged in size from several square centimeters to large lesions covering hundreds of square centimeters. All trees were left with the root systems exposed for the next year.

Of the 11 trees with *Armillaria* detected on their root systems 1998, four trees have been removed (Table 2). One tree was observed to have died between 1998 and 1999. Three trees were removed during 1999-2000; these trees were not examined before removal. Each of these trees originally had evidence of dieback. On the other 7 trees, *Armillaria* mycelial fans that occurred above the soil line were no longer viable one year after excavation. Mycelial fans were generally discolored and dry. In several instances, mycelial fans could not be relocated one year later. Isolations made from this tissue were negative for *Armillaria*. In all cases, *Trichoderma* species were isolated from the mycelial fans. *Trichoderma* is a soil-borne fungus that is well-known biological control agent. Commercial formulations of the fungus are available. However, all *Trichoderma* isolates from our plots were native to the orchard.

Overall vigor has improved for the seven remaining trees over the period of observation. Four trees had the same crown rating in 2001 as 2000; three trees improved between 2000 and 2001.

Most pear trees are planted with the root collar up to 50 cm below the soil line. Our previous research has shown that pears may be tolerant of infection on roots, but succumb quickly when infection is at the root collar. In many studies it has been shown that *Armillaria mellea* rarely colonizes trees above the soil line. Exposure of the root collar region may have several effects: 1) keep the bark dry and offset the influence of excessive moisture; 2) prevent initial infection of the root collar by rhizomorphs and restrict infections to peripheral parts of the root system; and 3) allow for recovery of infected tissues. It is our recommendation that all new pear trees be planted with the major roots and root crown as close to the soil surface as possible.

In 2002, we plan to expand the experiment to other orchards. Infected trees and non-infected control trees will be chosen in one or more orchards. Trees will be paired and one will be excavated and one left as is. This will result in four treatments: excavated infected, unexcavated infected, excavated not-infected, and unexcavated not-infected. Tree crown condition and *Armillaria* status will be rated and evaluated over several years.

Table 2. Status of root excavation experiment. All trees were observed with *Armillaria* on roots in 1998. Tree crown vigor ratings: 1, healthy, full crown with good shoot growth; 2, reduced top shoot growth; 3, most shoots with reduced growth; 4, dieback evident, leaves small and lighter in color; 5, dead.

Tree Number	**Crown Vigor 1998**	**Crown Vigor 1999**	**Crown Vigor 2000**	**Crown Vigor 2001**	***Armillaria* Status 2000**
P13	2.5	2.5	1.5	1.5	No *Armillaria* noted
Q12	3	3	2	2	No *Armillaria* noted
Q13	4.5	5	-	-	Tree removed 1999
BB8	2	1.5	1	1	No *Armillaria* noted, *Trichoderma* noted on N side roots.
CC8	3	3	3	2	No *Armillaria* noted, *Trichoderma* present on root surfaces; old lesions scattered
CC9	4	3.5	-	-	Tree removed 2000
CC12	4	3.5	1.5	1	No *Armillaria* noted
DD8	4	4	-	-	Tree removed 2000
DD9	3	3	2.5	2.5	No *Armillaria* noted
EE12	4	4	3.5	2.5	No *Armillaria* noted. *Trichoderma* on root surfaces.
EE13	4	4	-	-	Tree removed 2000