THOUSAND CANKERS DISEASE AND WALNUT TWIG BEETLE INSECTICIDE AND FUNGICIDE SPRAY STUDY

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ABSTRACT

Thousand cankers disease (TCD) caused by a fungus (*Geosmithia morbida*), which is vectored by the walnut twig beetle (WTB) (*Pityophthorus juglandis)*, has been found in many walnut growing counties since 2008 when it was first confirmed in Yolo Co., California. The disease is found primarily on black walnut tree species, but also on English walnut trees and Paradox rootstock throughout the state. Since 2009, several infected English walnut trees and Paradox rootstocks have been found in Sutter and Yuba counties typically on declining trees or those with low vigor. In addition to English walnut and Paradox rootstock infections, there is concern about the effect of TCD on black walnut seed trees for rootstock production. In August 2009, TCD was confirmed in a seed orchard of hybrid black walnut, *Juglans hindsii* X *(J. nigra* X *J. hindsii/J. californica*), on seedling Paradox hybrid rootstock in Sutter Co., California. In fall 2009, the infection rate of 217 of the black walnut hybrid trees was 24.4%. Presently, there are no effective insecticides or fungicides reported to control either WTB or *G. morbida*. The only management tool available is the removal of infected branches or trees followed by sanitation (grinding/burning) of the wood. Since 2010 we have tested the efficacy of selected insecticides and a systemic fungicide/tree stimulant applied by an airblast sprayer in the Sutter Co. seed orchard for controlling the beetle and/or the pathogen. We used pheromone-baited funnel traps to monitor the flight of WTB on a weekly basis from November 2011 until October 2014 when the trees were removed. Trap catches from 2013 and 2014 have been held in a freezer for future processing when funds are available. The overall rate of infection in September and October 2014 was 75%. This rate reflects a substantial increase over the previously recorded rates (65.5% in September 2012 and 53.7% in October and November 2013). The insecticide-only and insecticide + fungicide treatments have had the lowest percentages of infected trees from 2011 through 2013. In 2014, the insecticide treatment group had a significantly lower mean number of infected trees compared to the other treatments suggesting that insecticides may significantly reduce the proportion of trees that show active TCD symptoms and may slow its rate of increase.

OBJECTIVES

To conclude long-term testing of a fungicide/tree stimulant and two insecticides rotated on a monthly basis from spring through early fall for reducing tree mortality and tree decline from thousand cankers disease vectored by the walnut twig beetle in a hybrid black walnut seed orchard.

SIGNIFICANT FINDINGS

- The overall infection status of all trees in this heavily infested orchard has increased over time.
- The overall rate of infection in September and October 2014 was 75%. This rate reflects a substantial increase over the previously recorded rates (65.5% in September 2012 and 53.7% in October and November 2013).

- The insecticide treatment group had a significantly lower mean number of infected trees compared to the other treatment groups in 2014.
- Treatment with insecticides may significantly reduce the proportion of trees that show active TCD symptoms and may slow its rate of increase.
- The insecticide treatment group had trees with significantly healthier crowns than the fungicide alone treatment group. This supports the infection data and suggests that crown condition may be used as an indicator for infection status.
- The information developed on black walnut should be applicable to treatment in English walnut orchards should that become necessary.

PROCEDURES

In August 2009, TCD was confirmed in a seed orchard of hybrid black walnut, *Juglans hindsii* X *(J. nigra* X *J. hindsii/J. californica*), on seedling Paradox hybrid rootstock in Sutter Co., Califronia. A survey of 217 black walnut hybrid trees in fall 2009 showed 24.4 percent TCD infection in two seed orchard blocks. The study site established in 2010 had 11 replicates per treatment in a completely randomized design with five trees per replicate. In 2013, the owners removed all of the trees in the second block, which reduced the overall number of trees in the study. Because of the study design, the number of replicates removed from each treatment was not equal (control group declined from 49 to 34 trees; insecticide-only group declined from 54 to 49 trees; fungicide-only group declined from 53 to 28 trees; and insecticide + fungicide group declined from 53 to 23 trees). In late October 2014, the owners removed all of the study trees. The actual number of trees surveyed is shown in the tables. The four treatments in 2011 through 2014 included a fungicide/tree stimulant, two long residual insecticides rotated over a six month period (seven months in 2014), a fungicide/insecticide combination, and an untreated control for efficacy in reducing tree mortality (Table 1). Treatments were applied during the morning time by using a Rear's airblast pulblast/pakblast sprayer at 2.5 mph in 100 gallons/acre. Nozzles were adjusted so trunk to top of tree got coverage. Each plot was sprayed on both sides. The spray order was 1) fungicide, 2) insecticide, and 3) insecticide + fungicide. Spray timing was based on WTB trap catches recorded from previous years. The fungicide for all six sprays was Agri-Fos (Reliant) at 2 qts/A plus Pentra-bark at 10 oz/A. No Foam was added to prevent foaming and also in Brigade treatments. The 2 qt rate of Agri-Fos (Reliant) was a 1 qt/A increase over the application rate from 2010 through 2012.

In 2014, the total number of trees in the study was reduced again because the owners removed trees from the southern edge of the orchard before survey data could be collected in late October. Since we used a completely randomized design unequal numbers of replicates were removed; four replications of the insecticide treatment and two replications of the fungicide/insecticide combination treatment were not evaluated. Survey data for controls and crown rating of all trees in the study were recorded in September and all other treatments were surveyed in October 2014 (control data was rechecked in October).

Table 1. The insecticide spray materials (Carbaryl or pyrethroid) used and 2014 application dates:

Mar 27	April 30	May 30	June 30	July 29	Aug 28	Sept 29
Sevin XLR Plus 5 qts/A + Stickerbond 20 oz	Brigade 2 lbs/A	Sevin XLR Plus 5 qts/A + Stickerbond 20 oz	Brigade 2 lbs/A	Sevin XLR Plus 5 qts/A + Stickerbond 20 oz	Brigade 2 lbs/A	Sevin XLR Plus 5 qts/A + Stickerbond 20 oz

Sevin was selected since it is often used in forest and street tree applications to control bark beetles. Additionally, the orchard blocks were sprayed on July 3, 2014 with Onager plus Activator 90 for mites.

Walnut twig beetle monitoring: The WTB flight was monitored in Sutter Co. between Nov. 2011 and Oct. 2014 with four black plastic funnel traps baited with the male-produced aggregation pheromone. Traps were typically emptied weekly throughout the season. The trap catch data are under evaluation and will be tallied when funding becomes available.

Thousand cankers disease infection: Trees were assessed for WTB entrance or emergence holes, branch and stem staining caused by the *G. morbida* infection, and the condition of the crown. Survey data for controls and crown condition of all trees in the study was recorded on September 22, 2014, and controls rechecked and other treatments surveyed on October 27, 2014. To classify a tree as infected, it must have: 1) At least one WTB entrance or emergence hole, and 2) At least one branch stain that appears to be caused by TCD. Analysis of the rate of infection and crown condition ratings were evaluated by Proc GLIMMIX in SAS. A critical value of α=0.05 was used in the statistical analysis. Tukey's HSD was used for mean separation.

RESULTS AND DISCUSSION

Thousand cankers disease infection rate: The overall rate of infection in September and October 2014 was 75% (Table 2). This rate reflects an increase in infection from 2013 when it was 53%. In addition, all treatments had an increased percentage of infected trees from 2013 to 2014 (Table 3a). The change in infection status from 2012 to 2013 and from 2010 to 2012 is shown in Tables 3b and 3c, respectively.

Analysis of the rate of infection (Proc GLIMMIX in SAS) showed a significant treatment effect (*P*=.0007), which suggests that there is a significant difference in the infected trees between at least two of the treatments. A multiple mean comparison test with Tukey's HSD showed that the insecticide treatment group had a significantly lower mean number of infected trees than the control group (*P*=.0486), the fungicide only treatment group (*P*=.005), and the insecticide+fungicide treatment group (*P*=.0444) (Figure 1).

These results indicate that treatment with insecticides may significantly reduce the proportion of trees that show active TCD symptoms as compared to other treatments. This orchard is a heavily infested site, and all treatments showed an increase in the number of trees with active TCD infection, however, insecticide application may slow that rate of increase.

Treatment with Agri-Fos plus Pentra-bark ("fungicide") did not seem to have affected the proportion of trees with active TCD symptoms (as compared to the control group). The Agri-Fos plus Pentra-bark/insecticide combination treatment was one of the most effective treatments up until 2014. This difference in effect might be due to the loss of two replications of this treatment to tree removal activities in 2014.

Analysis of the crown ratings (on a scale of 1-5) (Proc GLIMMIX in SAS) showed a significant treatment effect (P=.0210), which suggests that there is a significant difference in the mean crown rating of trees between at least two of the treatment groups. A multiple comparison test with Tukey's HSD showed that the insecticide treatment had a significantly lower average rating, indicating a healthier crown, than the fungicide alone treatment (P=0.0398). This supports the infection data and suggests that the crown condition may be used as an indicator for infection status. In addition, there was a quadratic ($y = ax + bx^2 + c$) correlation between infection status and diameter of the tree trunks (DBH):a = 0.4002, b = - 0.1583, and c =- 1.7523;,R^2 = 0.27, P for all parameters < 0.05, which may suggest a difference in effectiveness of treatments based on tree size.

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Table 2. Infection status of trees (N=uneven replicates per treatment) based on survey data taken on 22 Sept., 2014, and 27 Oct., 2014.

Treatment	# of Infected Trees	% Infection
Control	23/29	79.3
Insecticide only	16/30	53.3
Fungicide only	25/28	89.3
Insecticide + Fungicide	11/13	84.6

Table 3a. Change in infection status from 2013 to 2014. Data excludes trees removed in 2013 and 2014.

Treatment	Change in # of Infected Trees	Change in % Infected Trees[1]
Control	Increased from 19 to 23/29	65.6 to 79.3%
Insecticide only	Increased from 10 to 16/30	33.3 to 53.3%
Fungicide only	Increased from 19 to 25/28	67.9 to 89.3%
Insecticide + Fungicide	Increased from 5 to 11/13	38.5 to 84.6%

[1]All treatments have increased in % of infected trees.

Table 3b. Change in infection status from 2012 to 2013

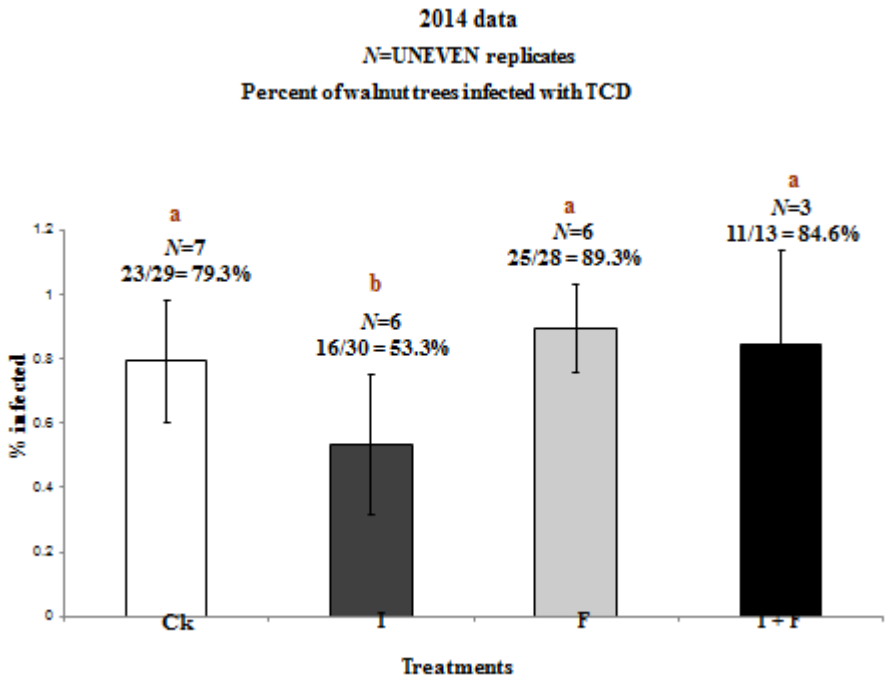
Treatment	Change in # of Infected Trees[a]	Change in % Infected Trees
Control	Increased from 23 to 24/34	67.6 to 70.6 %
Insecticide only	Decreased from 28 to 18/49	57.1 to 36.7 %
Fungicide only	Decreased from 26 to 19/28	92.9 to 67.9 %
Insecticide + Fungicide	Decreased from 16 to 11/23	69.6 to 47.8 %

[a] All treatments except for the control have decreased in % of infected trees. For handling data from 2012, we removed the trees from the data that were removed by the owner in 2013 in order to compare the two years.

Table 3c. Change in infection status from 2010 to 2012.

Treatment	Change in # of Infected Trees	Change in % of Infected Trees
Control	Increased: 17 to 23 to 36/49	36.1 to 46.9 to 73.4%
Insecticide only	Increased: 23 to 17 to 29/54	42.6 to 31.5 to 53.7%
Fungicide only	Increased: 28 to 35 to 45/53	52.8 to 60.0 to 84.9%
Insecticide + Fungicide	Increased: 17 to 14 to 27/53	32.1 to 26.4 to 50.9%

Figure 1. Percentage of walnut trees infected with TCD.



Tukey's HSD (*P*=.0486),
Ck=Check, I=Insecticide, F=Fungicide, I + F=Insecticide/Fungicide combination