INVESTIGATIONS IN THE MANAGEMENT OF SAN JOSE SCALE *DIASPIDIOTUS PERNICIOSUS* (COMSTOCK) (HOMOPTERA: *DIASPIDIDAE*) WITH HORTICULTURAL MINERAL OIL

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ABSTRACT

San Jose scale *Diaspidiotus perniciciosus* (Comstock) control was studied over a four-year period on four cultivars of plums in central California. The results of this study demonstrated that San Jose scale is effectively managed with a horticultural mineral oil application during the dormant season. No additional insecticide is required. Control of San Jose scale is influenced by the amount of oil applied per acre, the concentration of oil in the spray tank, and the timing of the application. In this study, best results were obtained with 8 gallons of horticultural mineral oil in a 400 gallon per acre mixture when applied in February. If 100 gallons per acre is applied, a minimum of 8 gallons of oil provided adequate control of San Jose scale. The harvest date of plums also influenced the severity of San Jose scale infestation. Plum varieties harvested in late June and early July are less infested than those harvested in August or September. Finally, preliminary studies resulted in a close relationship between infested spurs collected during the winter and fruit infestation with the late harvested Royal Diamond and Rosemary cultivars.

INTRODUCTION

Prior to 1945, San Jose scale (SJS) *Diaspidiotus perniciosus* (Comstock) was managed with various types of horticultural mineral oils (HMOs) (Davidson et al.). These ranged from kerosene to California Standard Grade Dormant Oils. They were applied during the dormant period, which ranged from December through late February. With the development of organophosphate insecticides agriculturalists began to include these new products with dormant oils and noticed an improvement in SJS control and, additionally, control of wintered peach twig borer, *Anarsia lineatella* Zeller. Once farmers realized peach twig borer (PTB) control occurred when an organophosphate insecticide was included, almost all dormant applications contained both an organophosphate and horticultural mineral oil. Until recently these dormant organophosphate and oil combinations were not know to cause environmental problems. However concentrations of organophosphate insecticides used in dormant applications have been found in the Sacramento River watershed (Holmes et al.). Fortunately, alternatives to organophosphates for PTB control have been developed (Barnett et al.) and this eliminates the need for organophosphate use in the dormant spray. Farmers are still unsure of the use of horticultural mineral oils to manage SJS. These studies were done to evaluate methods of applying the newer HMOs for controlling SJS in plums.

METHODS AND MATERIALS

The study was done in a 3.5 acre planting of late June harvested (Black Amber and Queen Rosa cultivars) late July harvested (Royal Diamond cultivar) and August harvested (Rosemary cultivar) plums. The orchard is 12 years old with an established SJS population. Field research was done over a 4-year period. Three types of experiments were performed from 2000 through 2003. The four plum cultivars were evaluated with each of the treatments. All tests were done with Exxon Dormant Spray Oil 100. This is a narrow range oil characterized by

with the exception of the Randall Electrostatic sprayer, used the same air carrier sprayer. Fruit harvest consisted of 200 fruit per plot from the central 8 trees of each plot.

The individual plots of the mixed Black Amber and Queen Rosa plums consisted of 64 trees and treatments were replicated four times in a randomized complete block design. Harvest occurred on June 16 (Black Amber) and June 21 (Queen Rosa). An analysis of variance was performed on the number of infested fruit per plot.

Two experiments were performed in the later harvested plums. Individual plots were smaller than the earlier harvested fruit. Using four replicates, one experiment compared application of 8 gallons of Exxon 100 Dormant Spray oil in 100 gallons and 400 gallons of mixture. There was also an untreated check. A paired experiment of 10 replications of the 100 and 400 gallon per acre mixture was also performed to evaluate efficacy in reducing SJS infestation. Royal Diamond plums were harvested on July 26 and Rosemary plums on July 28. Fruit sampling consisted of 200 plums from the central rows of each treatment. An analysis of variance was performed on the number of infested plums. In the following trials, all plots were 24 trees (4 trees by 6 trees).

During 2001 plots containing all of the varieties in the previous year were again randomized for further experiments. The Black Amber and Queen Rosa were treated with 8 gallons of Exxon Dormant Spray Oil on February 26, 2001. One treatment was applied in a 400 gallon per acre mixture. The second, paired treatment was made in 25 gallons per acre of spray mixture. A Randall Electrostatic sprayer was used to apply the 25 gallon per acre spray. There were six replications of each treatment. Two hundred fruit of each cultivar were evaluated for SJS infestation at harvest.

The Royal Diamond and Rosemary cultivars were also randomized and a paired comparison between HMO applied December 15 or February 15 was made. Eight plots were treated on each of these dates with 8 gallons of HMO in 400 gallons of spray mixture per acre. Treatments were replicated eight times. Two hundred fruit per plot, of each cultivar, were evaluated for SJS infestation.

In 2002 a single experiment with HMO was performed. All treatments were made with 100 gallons of oil and water mixture per acre. The treatments included a 2%, a 4% and an 8% oil water mixture per acre. There was also and untreated check comparison. Treatments were replicated six times and 200 fruit were sampled per plot for each of the two cultivars.

In 2003 a single experiment with HMO compared applications of 8 gallons of HMO in 400 gallons and 200 gallons of mixture per acre. There was also an untreated treatment. Plots were replicated six times.

During the winter of 2002, 100 spurs, approximately 3 inches in length, were sampled from the center two rows of each untreated plot in the two late harvested cultivars. The number of live scale and the number of infested spurs were recorded. The number of infested spurs collected was then correlated with the number of infested fruit at harvest. The harvest sample was 200 fruit.

RESULTS

The Black Amber cultivar was harvested on June 16, 2000. The 400 gpa application had 0.88% (± .85 SE), the 100 gpa had 1.38% (± .48 SE) and the untreated had 14.38% (±11.86 SE). The two oil treatments were not

was no significant difference (P>0.05, Fisher's PLSD) between the 100 gallon treatment and the untreated check infestation.

A second group of paired treatments were also evaluated (10 replications). The treatments compared in this paired group were the 400 gpa and the 100 gpa treatments. There was a highly significant difference between treatments (P<0.01, Fisher's PLSD). The 400 gpa treatment averaged 8.9% infestation and the 100 gpa treatment averaged 13.40% infestation.

The Rosemary cultivar was harvested on July 27, 2000. Infestation was 5.0% (± 4.08 SE), 7.75% (± 4.03 SE), and 18.75% (±8.06 SE) for the 400 gpa, 100 gpa, and untreated check, respectively. The 400 gpa treatment and 100 gpa were significantly different (P<0.05, Fisher's PLSD) from the untreated check. There was not difference between the 100 and 400 gpa treatments

The Rosemary cultivar treatments of 400 and 100 gpa mixture with 8 gallons of HMO were paired with 10 replications. There was a significant difference (P<0.05, Fisher's PLSD) between treatments. The 400 gpa treatment averaged 8.85% (± 4.43 SE) and the 100 gpa treatment averaged 13.4% (± 3.96 SE).

The first of the 2001 trials involved the comparison of the electrostatic spray application in 25 gpa compared to the dilute application in 400 gpa. Both these treatments included horticultural mineral oils at the rate of 8 gallons per acre. The Black Amber cultivar was harvested on June 19, 2001. In the first set of trials, the dilute and concentrate applications were both significantly different from the untreated treatment. Black Amber fruit averaged 3.75% (± 2.38 SE), 4.83% (± 2.40 SE), and 11.25% (± 7.02SE) infested fruit for the dilute, concentrate, and untreated treatments. Where the dilute and concentrate treatments were paired (separate experiment) there was a significant difference (P<0.05, Fisher's PLSD) between dilute and concentrate treatments. The 400 gpa dilute spray averaged 3.25% (± 1.43 SE) and the 25 gpa concentrate spray averaged 5.84% (± 2.16 SE).

The Queen Rosa cultivar was harvested on June 26, 2001. In the first set of trials the 400 gpa dilute spray was significantly (P< 0.05, Fisher's PLSD) different from the untreated check, but not different than the 25 gpa concentrate application. The 25 gpa concentrate application was not significantly different than the untreated check (P>0.05, Fisher's PLSD). Infestation averaged 2.84%, 8.34%, and 14.5% for the 400 gpa, 25 gpa, and untreated check, respectively. The paired comparison experiment did result in a significant difference (P<0.05, Fisher's PLSD) in scale infestation between the 400 gpa treatment and the 25 gpa treatment. The 400 gpa treatment averaged 4.5% infestation and the 25 gpa treatment averaged 8.33% infestation.

Where spray timing was investigated, the February timing resulted in better control than the December spray timing. The Royal Diamond cultivar was harvested on July 26, 2001. The spray timing trial resulted in better control of SJS with sprays applied in February. The San Jose scale infestation averaged 16.75% (±6.58 SE), 13.94% (± 4.15 SE), and 5.88% (± 3.25SE) for the untreated check, the December spray, and February spray, respectively. The February treatment resulted in significantly less scale infested fruit than the Untreated (P<0.05, Fisher's PLSD). There was no difference between the December treatment and the February treatment or the December and the untreated check (P>0.05, Fisher's PLSD).

The Rosemary cultivar was harvested on August 2, 2001. The San Jose scale infestation averaged 24.63%

The Rosemary cultivar infestation results were quite similar. The 8% oil concentration had significantly fewer infested fruit ($P<0.05$, Fisher's PLSD) than any of the other treatments. Fruit infestation averaged 27.75% (± 6.13 SE), 24% (± 7.01 SE), 20.08% (± 6.40 SE), and 7.67% (± 3.87 SE), for the untreated, check the 2%, 4%, and 8% treatments, respectively.

In 2003 a single trial comparing 8 gallons of oil in 400 gallon per acre and 8 gallons per oil in 200 gallon per acre treatment. The Royal Diamond cultivar was harvested on August 14, 2003. Infestation averaged 44.1% (± 10.40 SE), 27.2% (± 10.13 SE), and 17.4% (± 4.04 SE) for the untreated check, the 8 gallons of HMO in 200 gallons of spray mixture, and 8 gallons of HMO in 400 gallons of spray mixture. Both the 400 and 200 gallon treatment were significantly different from the untreated check ($P<0.05$, Fisher's PLSD) infestation. There was no difference statistical difference in infestation ($P>0.05$, Fisher's PLSD between the oil applications.

The Rosemary cultivar was harvested on September 11, 2003. Infestation averaged 44.2% (± 11.48 SE), 44.7% (± 8.47 SE), and 23.5% (± 14.08 SE) for the untreated check, the 4% oil treatment, and the 2% oil treatment respectively. The 8 gallon oil in 400 gallons of mixture treatment resulted in significantly less scale infestation that the other treatments ($P<0.05$, Fisher's PLSD). There was no statistical difference between the other treatments.

The relationship between spur infestation and harvest damage was statistically significant ($P<0.05$) for both the Royal Diamond and the Rosemary cultivars in 2002. The correlation coefficient for the Royal Diamond cultivar was 0.89. The correlation coefficient for the Rosemary cultivar was 0.82.

DISCUSSION

The studies presented have given information on the best use of a common HMO for control of SJS during the dormant season on four varieties of plum. All trials were conducted with a narrow range horticultural oil with a 50% distillation of 470 degrees Fahrenheit and a UR rating of 95.

San Jose scale infestation, in these experiments, was best managed with dilute sprays of 400 gallons per acre. Dilute applications are more important in managing SJS on late harvested plums. Where farmers are unable to use a 400 gpa dilute application, the higher rate of oil (up to 8 gallons per acre) in 100 gpa gave better performance than the lower concentrations of 2 and 4 gallons.

Applications in February were generally more effective than those in December. This is fortuitous because February dormant applications have been recognized as safer to use than those during December and January.

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