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IN THIS ISSUE

TENLINED JUNE BEETLE ATTACKING ALMOND ROOTS: A PAST PROBLEM RETURNS

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Keywords: tenlined June beetle, almond, root injury, Scarabaeidae

Introduction

The active immature stages (i.e., grub) of the tenlined June beetle (TLJB), *Polyphylla decimlineata* (Say) (Coleoptera: Scarabaeidae), commonly feed on roots of apple, cherry, prune and almond trees in California. The insect is native to the western United States. Recent reports indicate that the grubs have caused extensive damage to almond roots in Fresno, Madera, and San Joaquin counties (M. Freeman and Paul Verdegaal, personal communication), to the point of tree damage and death. Over the history of almond production in the San Joaquin Valley, this beetle has only been a significant problem in the Easton area of Fresno County and near Stockton, during the latter half of the 1980s. We do not know why the beetle diminished in importance after that, but it now appears to be reemerging as a significant problem in more widespread areas. Heavily infested orchards have been found only on sandy soils. Root damage and tree death have also been recently noted on walnuts, apples, and stone fruits in Stanislaus and Merced counties (Mike McKenry and M. Freeman, per. communication). Recognition of grub-induced damage to trees is difficult in the early stages of infestation. Typical tree symptoms include poor annual growth, loss of foliage, and leaf tip burn that may be confused with symptoms of "salt damage" or "almond leaf scorch" [caused by the bacterial

pathogen *Xyella fastidiosa*, and vectored by the glassy-winged sharpshooter, *Homalodisca coagulata* (Say)]. Limb dieback and tree death can follow. Presently, we do not know the extent, economically or geographically, to which TLJB is a problem on almonds or other fruit and nut crops.

The Challenge to Controlling TLJB

Although the TLJB grubs are easy to kill in the laboratory with conventional insecticides, the challenge to their management is delivering the toxic materials to the grubs in their natural habitat, which may be 2 inches to as much as 5 ft under the soil surface. Van Steenwyk et al. (1990) reported that experimental efforts to suppress field populations of TLJB grubs using granular applications of diazinon and carbofuran, disked and watered into the soil, gave limited control. They found that the grubs had to be actively feeding for the insecticides to work properly. Post-treatment grub mortality was limited to about 75 and 90%, for diazinon and carbofuran, respectively. The authors recommended that chemical controls be applied in September to target feeding first instars, and in May to target the third instars before they pupate. Unfortunately, delivering the pesticides to the third instars feeding deep underground is difficult, if not impossible. The UC Pest Management Guidelines for Almonds (http://www.ipm.ucdavis.edu/) states "There are currently no registered materials for control of this pest after trees are planted. Control requires the removal of infested trees and soil fumigation before replanting."

Our scant knowledge about the insect is another problem that limits our ability to take advantage of weak points in the pest's biology and ecology. For example, it is unknown how fumigated fields are re-infested or if the adult females fly. Evidently, the grubs move vertically in the soil over time, but the factors (e.g., moisture, temperature) influencing movement are unknown. Grubs tend to be a problem in sandy soils, but not in other soil types. It is unknown if soil texture makes a difference, or if there is some factor present or absent from other soils that makes them less preferable or more risky for TLJB grubs to complete development. More information on the biology of this species is badly needed to develop successful management techniques.

TLJB Biology and Ecology

Van Steenwyk and Rough (1989) and Van Steenwyk et al. (1990) provide the only published information on the biology of the beetle in almond orchards. Adults emerge from the soil from mid-June to mid-October, with peak emergence in early August. The adult males fly 1 to 6 ft above the ground in irregular patterns throughout the orchard, seeking females with whom to mate. Adult females wait for males on the soil surface within an inch of their emergence holes. It is believed that females emit a sex pheromone that attracts the males. Males may wait at the entrances to female emergence holes before the female ascends to the soil surface. Mating is quick, usually lasting less than 4 minutes. Mated females re-enter the soil and remain near the soil surface while laying their eggs. The cues that stimulate oviposition and the preferred locations for depositing eggs are unknown. Development from egg to adult requires 2 years, and eggs hatch around early August. Most first instar larvae are found in the first 12 in below the soil surface. They overwinter until the following March or April, when they molt into the second instar stage. Second instars may be distributed throughout the first 24 in below the soil surface. They feed in the soil until around June, at which time they molt into the third instar. The third instars overwinter and pupate, emerging as adults the following summer. This stage is more common at depths greater than 14 in below the soil surface and may be found feeding on tree roots deep (> 5 ft) in the soil.

Monitoring TLJB Populations

Monitoring is the key to effective control of most insect populations. TLJB adult males readily fly to light traps, but females do not (Van Steenwyk and Rough 1989). Light traps are easy to check, but involve a maintenance cost to power the light. This technique can become expensive if large acreages are to be monitored. Simple methods to monitor the females are non-existent, except to dig out females from the soil. Grubs must also be dug out of the soil. The presence of TLJB grubs or their exit holes does not confirm that nearby trees have experienced significant economic damage. Possible relationships between the numbers of beetle emergence holes on the soil surface and numbers of grubs or adult beetles in the vicinity have not been determined. It is unknown how many beetles use an exit hole to reach the soil surface. Commonly, one may excavate the roots of injured trees, but not find any TLJB grubs. Use of tree symptoms to reveal TLJB infestations can also be variable. The initial tree symptom of reduced annual vegetative growth, which is associated with TLJB damage, can be caused by many different factors including inadequate irrigation and root damage by various agents. Research may reveal that early detection and treatment is the key to managing TLJB. If so,

simple, easy, and inexpensive monitoring methods for tracking numbers of both grubs and adults would be extremely valuable.

Control Options Needing Investigation

Insect control may be divided into direct and indirect approaches (Johnson, *in press*). Direct approaches typically involve methods to increase the mortality of all stages of an insect or select stages (e.g., grubs), and usually require an agent (e.g., chemical or biological) to cause the mortality. Indirect approaches usually involve interference of the pest's biological needs or ecology. These would include mating disruption using a pheromone, trapping of insects using an attractant, use of resistant tree rootstocks, and removal or modification of necessary resources in the pest's biology (e.g., modifying soil texture by addition of organic material). Indirect approaches can be more successful and longer term than direct approaches, but require more knowledge and understanding of the pest's biology (Johnson, *in press*).

Chemical controls. No compounds are currently registered for TLJB control in almonds. New compounds are being used for control of other scarab beetles (e.g., Japanese beetle, *Popillia japonica* Newman) outside of California. One such compound is halofenozide, a molt-accelerating compound, which is marketed under the label Mach 2® (Dow AgroSciences). Other compounds used for white grub control in ornamental crops include imidacloprid (Merit®; Bayer) and isofenphos (Oftanol®; Bayer). Halofenozide and imidacloprid are usually applied prior to the hatch. These compounds should be evaluated to determine their efficacy in suppressing TLJB grubs. One major drawback is the low solubility and mobility of chemical controls. However, work by M. McKenry (UC Riverside / Kearney Agricultural Center) may provide solutions to increasing vertical chemical movement into the soil and should be evaluated in regards to TLJB control.

Biological controls. Other than general predators (e.g., birds, rodents), the only insect natural enemy identified attacking TLJB grubs is the scoliid wasp, *Campsomeris pilipes* (Saussure). This wasp searches out large TLJB grubs and lays an egg externally on the body (Sweetman 1958). The immature larva, which hatches from the egg, feeds on the beetle grub and eventually kills it. Development from egg to adult wasp takes about 4 to 8 wk depending on temperature. Although the parasitoid is common and seen frequently in the San Joaquin Valley, little is known about its impact on TLJB populations. However, given the 2-yr developmental cycle of the beetle, it is probable that several years may be necessary for the wasp to effectively reduce TLJB populations to non-damaging levels. More information is needed on this natural enemy and its impact on the beetle.

Insect pathogens may provide effective control of TLJB grubs. The bacteria *Paenibacillus* (= *Bacillus*) *popilliae* (Dutky) causes milky disease in infected Japanese beetle grubs and is commonly used for grub control in urban settings (Klein 2002, Tanada and Kaya 1993). This pathogen has to be ingested by the insect to kill it. Applications used to control Japanese beetle are usually delivered to the soil surface as a dry formulation. Liquid formulations have not been used yet. Pathogen strains are available that will infect TLJB grubs (Michael Klein, USDA-ARS, per. communication). However, this pathogen will also face the same problems as conventional insecticides with respect to delivering the infectious stage (i.e., spore) to the grubs deep in the soil. Some UC plant pathologists have suggested ways to move bacterial spores quicker and more efficiently through the soil solution and soil profile. A second pathogen, a recently discovered entomopathogenic nematode (*Steinernema scarabaei* Stock & Koppenhofer) (Albrecht Koppenhofer, Rutgers University, per. communication) appears to be highly specific to scarab grubs and may be a control option. The efficacy of both of these pathogens needs to be determined under field conditions.

Potential control via pheromones. Observations by Van Steenwyk and Rough (1989) suggest that the TLJB adult females emit a pheromone to attract males for mating. Identification and synthesis of this pheromone could potentially permit the manipulation of adult males. Ochieng et al. (2002) have identified components of a sex pheromone common to beetles in the genus *Polyphylla.* The simplest way in which pheromones could be used would be in traps to monitor population densities. However, it may be possible to either trap out most of the males in an orchard or to interrupt mating by saturating the orchard with the pheromone. Both methods would interfere with mating and significantly reduce the rate at which the beetle population increases. Research is needed in this area.

Resistant rootstocks, soil factors, and water stress management. The common rootstocks used for almond production vary in their resistance or susceptibility to various pests (Edstrom and Viveros 1996). Pest

resistance could be due to genetics, physical resistance to feeding, growth habit, or other factors. Most of the almonds in the areas affected by TLJB are planted with Nemaguard rootstock. Some of the trees are planted to Hanson Hybrid and Titan, and those trees are showing substantially reduced levels of symptoms above ground (M. Freeman, per. observation). It is not known if the beetle preferentially feeds on specific parts of the root system (e.g., the crown area, the larger roots, feeder roots, etc). However, it is easy to find damage to the larger roots on affected trees. Possibly, this is related to the large size of the grubs themselves. Field observations indicate that many of the emergence holes are located within 4 ft of the almond tree trunk.

Field observations have identified some trends with soil factors, such as the damage appears more severe on sandy soils than with trees on loamy soils, even in the same or adjacent fields. The damage appears more severe in orchards using low volume irrigation systems such as micro-sprinkler or drip. The almond acreage has increased dramatically in the Fresno area during the past 15 yr and the majority of the acreage is now using low volume irrigation.

Some type of water stress may be involved. In the eastern USA, grubs of the Japanese beetle and green June beetle, *Cotinis nitida* (L.), are major pests of turf grass. Christians and Ritchie (2002) state that grub feeding does not directly kill a lawn, but that drought stress, due to root injury, kills it. The presence of grub damage to lawns is most obvious during dry periods that may follow grub feeding. During July and August in California, irrigation of bearing almond trees is reduced before harvest to avoid shaker damage. It has been noticed in the field that almond trees start to exhibit above ground symptoms related to TLJB damage after the trees start bearing. If the initial tree symptoms are reflecting drought stress, one may be able to monitor significant TLJB populations with tree moisture measurements.

Conclusions

Currently, we do not know how many acres of almonds, or other tree crops, are being impacted by TLJB infestations. Growers need to be surveyed so the magnitude of this problem can be determined. Much work is needed to develop effective long and short term controls for TLJB. The identification of effective insecticides and insect pathogens will be of little value if mechanisms to improve delivery deep in the soil are not developed. Horticultural factors (e.g., rootstocks, water stress management, soil types) also need to be assessed for their influence on TLJB damage. Simple and inexpensive sampling techniques are needed to provide growers with information on TLJB populations in the soil. The potential to manipulate TLJB adults using pheromones (e.g., mass trapping, male confusion) needs to be evaluated. Although control of TLJB appears to be simple in concept, implementation may be highly challenging.

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EUROPEAN FRUIT LECANIUM (*Parthenolecanium corni*) IN-SEASON CONTROL WITH LOW-RISK INSECTICIDES

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Keywords: European fruit lecanium, scale, *Parthenolecanium corni,* grape, low-risk insecticide, Argentine ant

Abstract

Stylet oil and Neemix®, applied twice, and the insect growth regulator Applaud®, applied once and twice, were tested against the European fruit lecanium. Both stylet oil and Neemix® significantly reduced scale populations. Further studies are needed to determine the best timing for Applaud® treatments.

Introduction

The European fruit lecanium, *Parthenolecanium corni* (Bouché), is a common pest of prunes and other deciduous fruits. Recently, it has become prevalent and problematic in North Coast vineyards of Sonoma and Napa counties. Very high scale populations may cause vine stunting (Phillips & Clark 1993). Damaging scale populations take several generations (more than a year) to build.

Recent infestations in North Coast vineyards appear to be associated with the Argentine ant. It harvests the honeydew produced by the lecanium scale and interferes with the natural enemies controlling them, including *Metaphycus* spp., *Coccophagus* spp., *Encarsia* spp., and *Aphytis* spp. At the present time, very few insecticides are available for ant control. Lorsban® suppresses ant populations for a period of 2 to 3 months.

European fruit lecanium overwinters as second instar nymphs, under bark on the trunk or on the undersides of cordons and spurs. Early in the spring, the nymphs develop into females which lay eggs beneath their bodies. Eggs hatch in May and early June, and the first instar nymphs move to the shoots and leaves of the current growth where they molt to second instar nymphs in June and July. Historically, European fruit lecanium attacking fruit trees has been controlled by delayed dormant oil sprays or organophosphate sprays directed against newly hatched nymphs (Smith & Phillips 1961). Delayed dormant sprays are less effective in grapes because overwintering scales are protected under the bark from insecticide contact, and because organophosphate insecticides may become of limited use. However, insecticide intervention in the springtime against active crawlers could limit scale population development. This trial investigated the use of oils and insect growth regulators targeted at the crawlers in the spring.

Material and Methods

The goal of this study was to evaluate the effectiveness of stylet oil, azadirachtin (Neemix®), and the insect growth regulator buprofezin (Applaud®), against first and second instar nymphs when applied in the spring. A replicated trial was conducted in a 10-year old Chardonnay vineyard in the Carneros area of Sonoma County. The trial consisted of five treatments with 10 replications in a randomized block design. The treatments were: 1) stylet oil applied twice, 2) Neemix® applied twice, 3) Applaud® applied twice, 4) Applaud® applied once and 5) water as the control (Table 1). Each replicate consisted of 10 vines. All insecticides were applied with a backpack sprayer in 100 gallons of water per acre. Applications were made on 14 June, coinciding with 50% egg hatch; and on 12 July, coinciding with 99% egg hatch and with the population at approximately 50% first and 50% second instar. No third instars were observed up to this time.

The plots were sampled one and three weeks after each application, on 21 June, 5 and 19 July, and 2 August 2002. We sampled five leaves per replicate, taking one leaf per vine in each of the five center vines (total of 50 leaves per treatment). Basal leaves were selected, since the females lay their eggs on one-year or older wood, and the crawlers migrate to the basal leaves first. Leaves were examined under a dissecting microscope, and the number of first and second instar nymphs, alive and dead, were recorded.

The mean number of live, first and second instar nymphs were analyzed. Data were transformed by log (X+1) and analyzed using ANOVA. Mean separation was determined by Tukey's HDS.

Results and Discussion

The proportion of first instar nymphs remaining alive after treatment is presented in Figure 1. The evaluations performed one and three weeks after the first application showed that numbers of first instar treated with Neemix® were significantly reduced, compared to the control (F = 5.72; df = 4, 9; $P < 0.001$ for 21 June and F = 5.10; df = 4, 9; $P < 0.002$ for 5 July). After the second application on 12 July, populations of first instar nymphs were

significantly reduced in both the stylet oil and Neemix® treatments (F = 10.63; df = 4, 9; P < 0.001 for 19 July and F = 13.93; df = 4, 9; P < 0.001 for 2 August). Applaud® is an insect growth regulator that acts when the nymphs molt to the next stage. Thus, mortality of first instar nymphs was not expected.

The proportion of second instar nymphs alive three weeks after treatment is described in Figure 2. Populations of second instar nymphs were lower (F = 4.43; df = 4, 9; P < 0.005) in the Neemix® treatment three weeks after the first application. After the second application, populations were reduced (F = 4.38; df = 4, 9; P < 0.005) in both the Neemix® and stylet oil treatments, respectively.

There was no significant difference between Applaud®, applied once on 12 July, and the control. At the time of this application, 50% of the population were first instars (nymphs), and the remaining 50% second instars. The treatment in which Applaud® was applied twice, on 14 June and 12 July, was also not significantly different from the control. However, since some reduction did occur, it is possible that the timing of the application was too late. The data presented here are preliminary, and further studies are needed to determine if Applaud® would be more effective if applied when the majority of the population is first instars (nymphs).

Both stylet oil and Neemix® reduced the scale population by more than 67%, as compared to the nontreated control. Stylet oil also may be used for powdery mildew control early in the season, at 2% rate. Further studies are needed to determine if using stylet oil for powdery mildew control when crawlers are present would prevent the build up of scale populations to damaging levels.

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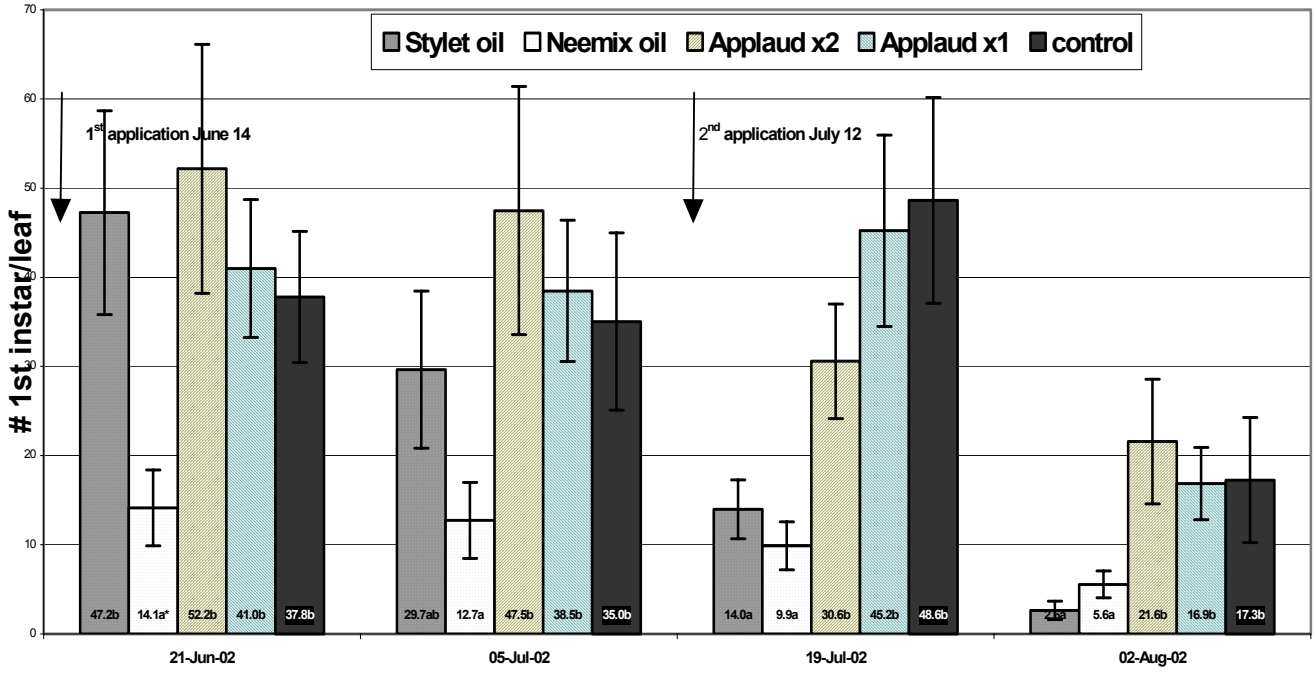
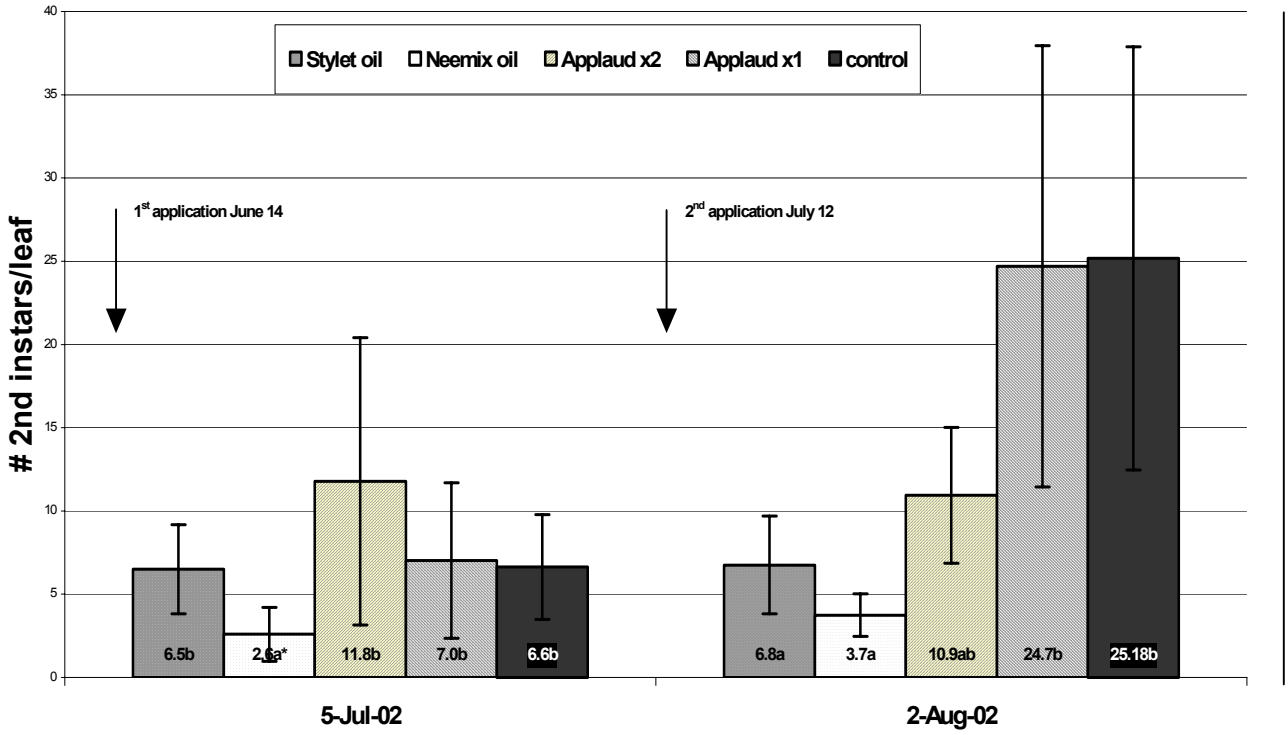
Table 1. Summary of insecticide treatments, rates, and dates of application employed in the control study of the European fruit lecanium scale in grapes.

Insecticide	Rate	Date Applied
Stylet oil	1.5 %	14 June & 12 July
Neemix® 4.5	16 oz/acre	14 June & 12 July
Applaud® 70 WP	0.5 lb/acre	14 June & 12 July
Applaud® 70 WP	0.5 lb/acre	12 July (once)
Control	Water	14 June & 12 July



*Number followed by the same letter at each date is not significantly different (Tukey's HSD)

Figure 1. Number of 1st instar European fruit lecanium nymphs per leaf present during the evaluation of the five insecticide treatments one week and three weeks after each application.



* Number followed by the same letter at each date is not significantly different (Tukey's HSD)

Figure 2. Number of 2nd instar European fruit lecanium nymphs per leaf present during the evaluation of five insecticide treatments three weeks after each application.