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Control of overwintering *Quadraspidiotus perniciosus* (Comstock) on pome fruits in northern Italy (Emilia-Romagna region)

Abstract - Two pesticide field trials were carried out against overwintering San José Scale, *Quadraspidiotus perniciosus* (Comstock) (Homoptera Diaspididae) on apples (in 2000) and pears (in 2001) in the Emilia-Romagna Region of northern Italy. The active ingredients tested were mineral oil (2.7%), mineral oil and imidacloprid (2.7%), buprofezin added to mineral oil (as a wetting agent) (0.14% + 0.5%), and lime sulphur (25/75); different timings of sprays were also tested. The experimental design consisted of a randomised block with at least four replicates. The efficacy of the treatments (mortality) was estimated by counting scales (dead and alive). Twenty randomly selected, infested shoots (1-2 years old) and at least 400 scales were examined from each plot. The results showed that a high level of mortality was caused by all the treatments tested. The choice of which active ingredient used (or mixture thereof) depended on what other pests were present at the time of application (e.g. *Dysaphis plantaginea* Passerini, *Hoplocampa brevis* Klug).

Key words: *Quadraspidiotus perniciosus*, apple, pear, insecticides, winter control.

INTRODUCTION

Quadraspidiotus perniciosus (Comstock) (Homoptera Diaspididae), the San José Scale (SJS), is one of the main pest threats of pome fruits, although it attacks also many other fruit, shrub and ornamental species. The SJS inflicts direct damage by feeding on the sap, causing the affected tissues to dry out. Damage can result in the total or partial loss of plants, as well as reducing the yield and marketability of the fruit, so the economic impact can be serious. Even just a few individuals found in a commercial shipment can result in the its rejection by markets (Tremblay, 1995).

Careful management is required to achieve scale-free harvests; this may mean resorting to specific treatments when necessary. In Emilia-Romagna the practical intervention threshold usually adopted is detection of SJS in an orchard. Here, SJS has three generations per year and disperses via plant-to-plant contact or by the wind, so growers and extension officers must monitor plants carefully and continuously throughout the growing season.

The usual winter preventive measures involve the application of mineral oil, lime sulphur or buprofezin (a growth regulator) (Grumberg, 1967; Mayer and Randell, 1973; Westigard *et al.*, 1986; Celli & Nicoli, 1989; Antropoli *et al.*, 1994; Pollini & Bariselli, 1998; Pasqualini & Civolani, 2000). These, and other treatments, are used also to limit the number of migrating SJS crawlers during the growing season (Pollini & Bariselli, 1998; Pasqualini & Civolani, 2000), but have not always proven effective. The least acceptable feature of these treatments, which often involve repeated applications of relatively non-selective products, is the adverse impact on natural enemy populations.

The winter control strategy is held to be best both technically and environmentally, as *Q. perniciosus* almost always overwinters as vulnerable first-instar larvae (Gambaro, 1947, 1955), and beneficial insects like *Anthocoris nemoralis* F. are inactive in winter shelters at this time. This study examined the winter control strategy in greater detail to assess the performance of mineral oil; findings were expressed as mortality of overwintering immature stages. The products tested were: mineral oil; lime sulphur; buprofezin (plus 0.5% of mineral oil as wetting agent, as usually recommended in Emilia-Romagna); and a mixture of mineral oil plus imidacloprid (the latter is used to control the rosy apple aphid *Dysaphis plantaginea* (Passerini) on apple, and pear sowfly *Hoplocampa brevis* Klug, on pear). The information obtained could assist decision-making on what timing, application method and active ingredient to use for winter control of *Q. perniciosus,* depending on the pest situation in the field.

MATERIALS AND METHODS

The trials were conducted on orchards of apple (in 2000) and pear (in 2001) in Ferrara Province (Table 1). The treatments targeted the SJS overwintering generation and employed different application times and products (Tables 2 and 3); they were delivered using a backpack pump (model KWH with air convection) at standard spray volumes (15 hl/ha). The active ingredients used were mineral oil (2.7%), mineral oil and imidacloprid (2.7%), buprofezin added to mineral oil as a wetting agent (0.14% + 0.5%), and lime sulphur (25/75); different timings of sprays were also tested. The trial layout was a randomised block design with five replications in 2000 (on apple) and four in 2001 (on pear). Sampling was carried out following the OEPP protocol [PP1/131(2)]. Immature stage mortality rates were recorded before and after treatments

Table 1 - Orchard profile.

Year	Orchard	Species	Cultivar	Age	Training system
2000	Cavicchi	apple	Imperatore	32	palmette
2001	Paltrinieri	pear	Abbé Fétel	30	palmette

Table 2 - Treatment schedule chart (2000).

Active ingredient	% a. i.	Commercial name	Dose (%)	Application time	Date
Untreated					
Mineral oil	80	Oliocin	2.7	Leaf fall	17/12/99
Mineral oil & imidacloprid	80 & 0,4	Experimental	2.7	Leaf fall	17/12/99
Lime sulphur	22,5-23,5	Polisenio	25/75	Green tip	27/03/00
Mineral oil	80	Oliocin	2,7	Green tip	27/03/00
Mineral oil & imidacloprid	80 & 0,4	Experimental	2,7	Green tip	27/03/00
Mineral oil	80	Oliocin	2,7	Tight cluster	07/04/00
Mineral oil & imidacloprid	80 & 0,4	Experimental	2,7	Tight cluster	07/04/00
Buprofezin + oil*	25 + 80	Applaud + Oliocin	0,14 + 0,5	Tight cluster	07/04/00

* as wetting agent

Table 3 - Treatment schedule chart (2001).

Active ingredient	% a. i.	Commercial name	Dose (%)	Application time	Date
Untreated					
Lime sulphur	22,5-23,5	Polisenio	25/75	Green tip	14/03/01
Mineral oil	80	Oliocin	2,7	Tight cluster	19/03/01
Mineral oil & imidacloprid	80 & 0,4	Experimental	2,7	Tight cluster	19/03/01
Buprofezin + oil*	25 + 80	Applaud + Oliocin	0,14 + 0,5	Tight cluster	19/03/01

* as wetting agent

in each plot, using a binocular microscope to examine 20 randomly selected, infested shoots (1-2 years old, each 20-cm long) and at least 400 scales from each plot. The mortality data per plot, expressed as percentages, were transformed in *arcsen ÷(x)* before analysis of variance (ANOVA), followed by the LSD test ($p<0.05$) for means separation.

RESULTS

Results for the years 2000 and 2001 are shown in Tables 4 and 5 respectively. They highlight not only the high natural mortality rate of first and second instar larvae,

Table 4 - Results on apple (2000).

Active ingredient	Application time	1999, 10th Dec. (pre-treatment)	2000, 20th Jan.	2000, 23rd Mar. (pre-treatment)	2000, 25th Mar. (pre-treatment)	2000, 4th Apr.	2000, 1st May
Untreated		40.3 ns	46.7 ns	47.5 a			68 a
Mineral oil	Leaf fall (1999)	29.6 ns	52.4 ns	98.2 b			99.6 cd
Mineral oil & imidacloprid	Leaf fall (1999)	39.2 ns	47.7 ns	99.4 b			99.9 d
Mineral oil	Green tip				44.6 ns		98.4 cd
Mineral oil & imidacloprid	Green tip				42.1 ns		97.8 c
Lime sulphur	Green tip				45.6 ns		87.2 b
Mineral oil	Tight cluster					55.1 ns	98.4 cd
Mineral oil & imidacloprid	Tight cluster					54.3 ns	99.3 cd
Buprofezin + oil	Tight cluster					49.6 ns	98.4 cd

Table 5 - Results on pear (2001.

Active ingredient	Application time	2001, 15th March (pre-treatment)	2001, 19th March 2001, 20th April	2001, 20th April
Untreated			35.8 ns	63.2 a
Lime sulphur	Green tip	34.96		87.6 b
Mineral oil	Tight cluster		36.1 ns	95.8 c
Mineral oil & imidacloprid	Tight cluster		40.3 ns	95.5 c
Buprofezin + oil	Tight cluster		38.6 ns	90.2 bc

as monitored over the two trial years, but the progressive rise in mortality during the winter until it peaks at values over 60% in the spring (untreated).

Statistical analysis indicated that lime sulphur was slightly less effective than the other tested products. The mortality rate for Buprofezin + oil (as a wetting agent) was below expectations in 2001, although obviously its action should also be evaluated for its effect on the subsequent generation, since this is a trait linked to the performance of growth regulators (CSI) in general.

The timings of the treatments did not result in any substantial differences between the tested products. The insecticide activity of the products probably occurs during the moult from the first to the second nymphal stage (Mazzoni, 2000); in 2000, this occurred before the sampling on March 23 (Table 4). The mortalities on apple were generally higher than those on pear; this was probably related to the degree of wrinkling of the bark, which may effect the degree of coverage by sprays and hence their effectiveness.

DISCUSSION

In both trial years, this study documented the high natural mortality rate and its increase as the winter progressed. All the tested products were remarkably effective in the winter control of *Q. perniciosus*. No substantial differences between products were found except for lime sulphur, whose performance was slightly below expectations. Addition of Imidacloprid (the main targets of which are other species of Homoptera (aphids) or Hymenoptera (Tentredinidae)) did not substantially enhance the performance of oil against SJS.

Treatment timing did not appear to significantly affect the final results. The mortality due to the treatments probably occurs during the moult into the second nymphal stage, or the subsequent moult. The response on pear proved somewhat less effective than on apple, probably due to differences in bark texture. Thus, given the attendant difficulties in controlling summer attacks of SJS, the overall data indicate that winter treatments against this scale insect pest provide a satisfactory control strategy.

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