EARLY SEASON APPLE PEST MANAGEMENT: CONTROL OF TWO SPECIES OF SCALES (HOMO.:DIASPIDIDAE) AND BRUCE SPANWORM (LEP.:GEOMETRIDAE) WITH METHIDATHION[1]

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ABSTRACT

The organophosphate insecticide, methidathion, proved to be more efficacious for the control of San Jose scale (*Quadraspidiotus perniciosus* (Comstock)) and European fruit scale (*Q. ostraeformis* (Curtis)) than dormant oil when applied at the tight cluster stage of bud development. The compound also provided effective control of Bruce spanworm (*Operophtera bruceata* (Hulst)) and did not cause excessive mortality of the predaceous mites responsible for the biological control of orchard phytophagous mites. Methidathion use could be integrated into existing orchard pest management programs by using currently accepted sampling schemes for the above pest organisms to determine when thresholds requiring treatment have been exceeded.

INTRODUCTION

In British Columbia apple orchards, San Jose scale and European fruit scale are serious pests in view of the requirement of several overseas export markets for apples to be free of San Jose scale. On apple fruit, European fruit scale is almost indistinguishable from San Jose scale and hand sorting to remove scale infested apples increases packaging costs that can best be reduced through improved control measures in the orchard.

Currently recommended control procedures for San Jose scale involve applications of petroleum oils during the dormant period with later applications of the organophosphate diazinon for control of the flying males in order to disrupt mating (Downing and Logan 1977) and for control of summer crawlers. These procedures have inherent logistical and technical difficulties that cause them to be less than 100% effective. The oil sprays are difficult to apply because of adverse winter weather and because equipment limitations often prevent the complete tree coverage which is necessary for effective scale control. In some years the males emerge during bloom when insect pollination is essential, which prohibits coordination of spray application with male emergence. The crawlers are very small and difficult to detect, thereby making the timing of spray applications difficult.

Control of European fruit scale currently relies on the application of dormant oil only, as the males almost always emerge during bloom and emergence of crawlers extends over most of the summer which would therefore require repeated diazinon applications.

The objectives of this project were to:

1. determine if the organophosphate, methidathion, could be used during the dormant period to control both species of scale;
2. determine if this single spray could replace all or any of the currently recommended sprays;
3. measure the effects of methidathion on predaceous mites in order to determine the potential impact of the compound on the integrated mite control program;
4. measure the effects of methidathion on the early season bud-feeding Bruce spanworm.

MATERIALS AND METHODS

For all treatments using methidathion (S-(2,3-dihydro - 5 - methoxy-2-oxo-1,3,4-thiadiazol- 3-yl-methyl)-0,0-dimethyl-phosphorodithioate) the commercial 25 EC formulation (Supracide®) was used. Dormant oil used was Axis dormant spray oil (viscosity approximately 180-220).

San Jose Scale. 1982

A commercial orchard in Osoyoos, B.C. consisting of mixed Red Delicious, Golden Delicious and Winesap apple trees, about 20-years-old and planted 6 x 6 m, was divided into 6 unequal-sized plots that each contained at least 6 trees heavily infested with San Jose scale (SJS). Red Delicious trees were used as much as possible but Winesaps were included as necessary. Two guard rows were left between each plot. Treatments were assigned randomly and aplied at the 15 mm green stage of bud development on the Red Delicious trees, using an air-blast sprayer calibrated to deliver 2247 L/ha. At harvest, 500 apples were sampled from each of the 6 designated trees/plot. Treatments and rates of application are shown in Table 1.

1984

The same orchard was used again with some operational differences. Only Red Delicious trees were used, treatments were applied during the tight cluster stage of Red Delicious bud development, and only 400 apples per tree were sampled at harvest.

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TABLE 1. Effect of several treatments on incidence of San Jose scale on fruit at harvest in an Osoyoos, B.C. orchard.

Treatment	Rate/ha	Mean Percent Infested Fruit		
		Red Delicious	Winesap	Total
		1982		
Oil	90.0 L	14.04	-	14.04 a 1*
Methidathion	5.6 L			
+				
oil	45.0 L	1.64	0.05	0.58 a 2
Methidathion	11.2 L			
+				
oil	45.0 L	0.23	-	0.23 a 2
Methiadathion	5.6 L	2.70	-	2.70 a 2
Methidathion	11.2 L	0.60	-	0.60 a 2
Control	no treatment	82.40	58.90	74.57 b
		1984		
Oil	90.0 L	2.61 ab**		
Methidathion	5.6 L			
+				
oil	45.0 L	0.21 a		
Control	no treatment	4.65 b		

*Means followed by the same letter are not significantly different(P 0.01, SNK)
Means followed by the same number are not significantly different(P 0.05, SNK), the control treatment was not included in the analysis for 1982.
**Means followed by the same letter are not significantly different(P 0.05, SNK)

European Fruit Scale. 1983

In a commercial orchard in Summerland, B.C. consisting of 70 to 80 year old standard McIntosh apple trees, 7 treatments (Table II) were applied to blocks of about 20 trees all heavily infested with European fruit scale (EFS). All treatments were applied at the tight cluster stage of bud development using an air-blast sprayer as above. Control effectiveness was measured by harvesting 500 apples (or all of the apples) from 6 randomly selected trees in each block.

1984

In the same orchard, the same treatments and methods were used except that treatment block assignments were re-randomized.

For all of the above tests, the harvest data (as percent infested fruit) were transformed to arcsine square root (x) and subjected to an analysis of variance. Differences between means were tested with either the Student-Newman-Keuls test (SNK) or Duncan's Multiple Range test.

Non-Target Organisms

Phytophagous and predaceous mites were sampled by taking 15 leaves from each of 6 trees per plot in both of the orchards during both years and processing them by standard leaf brushing techniques in the laboratory (Morgan *et al.* 1955). These samples were taken during the period when the numbers of European red mites (*Panonychus ulmi* Koch) were increasing or had peaked. One sample was taken/orchard/year.

Predaceous Mite Mortality Tests

In addition to the mite counts described, two tests were conducted to determine the impact of methidathion on predaceous mites. In 1983, a planting of 23 year old Golden Delicious apples was used to test the time of application of methidathion on predator mortality. There were 3 plots for each treatment and 4 trees per plot in a completely randomized experimental design. Guard trees were left between treatment rows and one guard tree was left between adjacent plots. Treatments were applied with a hydraulic boom sprayer operating at 1035 kPa, 3.10 kmh and calibrated to deliver 24.8 L/min or 2247 L/ha. Methidathion was applied at a rate of 5.6 L/ha, and treatments were applied at the following stages of tree bud development; 15 mm green, tight cluster, pre-pink, pink and petal fall. Mites were sampled by taking 10 leaves/tree from each of the trees in each of the plots and processing them in the laboratory using standard leaf brushing techniques. Three samples were taken: the first on 83.05.10, the second on 83.05.19 and the last on 83.06.03.

In 1984 a similar experiment was conducted using a block of 23 year old Red Delicious apple trees. In this experiment there were 5 trees/plot and samples were taken on 84.06.05 and 84.06.20 and processed as described.

Bruce Spanworm

In the same orchard used for the EFS trials in 1984, 25 bud clusters were taken from 6 randomly selected trees from each of the 7 treatment blocks. The clusters were then examined for the presence of live or dead spanworm larvae. Mean numbers of larvae varied between clusters, so an analysis of variance was performed on the percentage of dead larvae per cluster. Means were compared with Duncan's Multiple Range Test and the Student-Newman-Keuls test.

RESULTS AND DISCUSSION

In 1982, because of large differences between scale infestation levels on the harvested apples from the control block and the remaining blocks, an analysis of variance was performed on the remaining blocks in addition to an analysis of variance of all treatments. When the treatments were considered together (including the control) all were equally effective relative to the control (Table 1). Comparing treatments after the exclusion of the control block suggests that all of the methidathion treatments were equally effective and superior to the oil treatment. However, the oil treatment did not control SJS at a commercially acceptable level. It is for this reason that the additional malathion sprays are recommended. Methidathion at 5.6 L/ha combined with oil gave commercially acceptable control of SJS during both years of the study. The treatments in this study were applied under ideal weather conditions of little or no wind using a carefully calibrated sprayer. However, commercial growers are often not able to wait for ideal weather conditions and their sprayers may not always be accurately calibrated, conditions which result in poor or erratic spray coverage and scale control. SJS control with methidathion is probably not so sensitive as oil treatment to application conditions.

There were no significant differences between treatments in the number of phytoseiid mite predators found during the mid-summer peak of European red mite which occurred in significantly larger numbers only in the control block in 1982. No significant differences between treatments in either predaceous or phytophagous mites were found in 1984.

Results of the EFS trials were similar in both years (Table 2). Oil applied by air-blast sprayer was not so effective for scale control as methidathion, whereas oil applied by hand-gun was equally effective. The trees used in this experiment were very large and had very rough bark, both of which limit the effectiveness of spray coverage with an air-blast sprayer. Poor EFS control is probably a consequence of large numbers of the insect under flaking bark and on new growth in the tops of the trees. Oil

TABLE 2. Effect of several treatments on incidence of European fruit scale on fruit at harvest in a Summerland, B.C. orchard.

Treatment	Rate/ha	Mean Percent Infested Fruit	
		1983	1984
oil	90.0 l	1.13 ab[1]	6.15 a
oil - hand gun	to drip	0.20 a	3.12 b
methidathion	5.6 l		
+			
oil	45.0 l	0.52 a	1.82 b
methidathion	11.2 l		
+			
oil	45.0 l	0.27 a	2.27 b
methidathion	5.6 l	1.27 ab	3.62 b
methidathion	11.2 l	0.47 a	3.07 b
control	no treatment	2.10 b	9.23 a

[1]Means within columns followed by the same letter are not significantly different (P<0.05, SNK).

applied in large quantities by hand-gun gives effective coverage and acceptable control. Unfortunately, the time commitment and inconvenience of hand-gun applications limit their use. Significantly better control of EFS without the stringent coverage requirements of oil can be achieved with methidathion.

There were no significant differences between phytophagous or predaceous mite populations during either year of the study.

The results of the predator mortality tests showed no significant difference between time of application of methidathion for the phytoseiid predator, *Typhlodromus occidentalis* (Nesbitt), in 1983 or for the stigmaeid predator, *Zetzelli mali* (Ewing) in 1984.

Bruce spanworm larval mortality was significantly higher in trees treated with methidathion than in those receiving either no treatment or dormant oil (Table 3). Dormant oil does not control this insect. The level of control effected by methidathion at either rate, with or without oil would be commercially acceptable. Better control might have been realized, but a lengthy period of cool weather increased the spanworm hatching period, thus allowing survival of late hatching larvae.

The current recommendation for Bruce Spanworm control is an application of an organophosphate pesticide at the pink bud stage. Previous work by McMullen (1973) indicated 90 to 100 percent control with such an application. Our results are comparable in terms of commercially acceptable levels of control and we believe that the tight cluster methidathion application can replace the pink spray.

Pest Management Recommendations

The integration of the tight cluster methidathion spray into existing orchard pest management regimes could proceed as follows:

1. Harvest fruit samples and assess for incidence of SJS and EFS to determine the dormant period control measures. Based on previous experience, areas with high counts of SJS or in orchards with chronic EFS problems, this step could be omitted and a spray applied routinely at least every other year. Our results suggest that for SJS, the methidathion spray could replace the dormant oil spray, the petal fall spray for male mating disruption, and the two summer crawler sprays, thus resulting in a considerable reduction in pesticide usage and control effort. Research is underway to clarify the relationship between pheromone and sticky trap captures of SJS males and eventual fruit infestation. A positive relationship would enable monitoring of the male population levels with traps and thus the efficacy of dormant control measures could be determined. If the measures were unsuccessful, summer crawler sprays could be applied using the degree day timing model currently being developed.

2. Bruce spanworm control is an automatic benefit of the methidathion spray. However, in those orchards with no scale problem, but with ab-

TABLE 3. Effect of several treatments on incidence of Bruce Spanworm in apple blossom clusters in a Summerland, B.C. orchard.

Treatment	Rate/ha	Mean Larvae	% Dead
oil	90.0 1	11.00 ac[1]	0.00 a[2]
oil - hand gun	to drip	12.67 b	1.52 a
methidathion + oil	5.6 1 + 45.0 1	8.50 abc	35.98 b
methidathion + oil	11.2 1 + 45.0 1	11.17 bc	85.63 c
methidathion	5.6 1	8.33 abc	53.55 b
methidathion	11.2 1	3.67 a	79.38 c
control	no treatment	6.33 ac	4.23 a

[1]Means within columns followed by the same letter are not significantly different (Duncan's Multiple Range Test, P<0.05).

[2]Means within columns followed by the same letter are not significantly different (Newman-Keuls test, P<0.01).

normally high spanworm populations, the methidathion spray could prove to be more useful than the currently recommended pink spray as it will also control some leafroller species (H. Madsen, personal communication). Work is currently in progress to measure the relationship between males captured in pheromone traps in the fall and larval populations in the spring. This information could also be used to determine the need for spring control measures.

3. Our experiments suggest that methidathion applied at the recommended rate of 5.6 l/ha does not cause significant predaceous mite mortality. This observation will require further investigation in other locations and subsequent years.

4. There is some evidence that methidathion applied at tight cluster can have detrimental effects on insect pollinators if dandelions on the orchard floor or adjacent deciduous stone fruit trees are in bloom. Cultural practices may need modification to overcome this problem.

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COMPARISON OF HONEY BEE QUEENS OVERWINTERED INDIVIDUALLY AND IN GROUPS

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SUMMARY

Productivity of honey bee queens, as measured by area of sealed worker brood and net weight of colonies, was generally higher with queens overwintered in 2-frame nuclei, than with queens overwintered in a group. Poor acceptance and supercedure of group overwintered queens suggest that this method of storage is not yet acceptable for commercial use. Survival of the nucleus queens was low in outdoor 2-frame units during the winter, but improved with an indoor system. Overwintering queens indoors in 2-frame nuclei and outdoors in 3-5 frame nuclei with supplemental feeding of carbohydrate in late winter should provide a source of queens which could partially fulfill market demands in spring.

INTRODUCTION

Two systems of bee management are commonly employed in the cold beekeeping regions of Canada. Traditionally, beekeepers destroy all bees in the fall after removing honey, and renew their apiaries in the spring with imported packages containing 0.9-1.8 kg of worker bees and a queen. Increasingly however, beekeepers are overwintering a portion of their colonies and reducing the need to import packages. Nevertheless, large numbers of packages are still imported annually from the United States; in 1982, 350,000 packages valued at $10 million were imported (Winston 1983).

Recognition of impending threats to North American apiculture from two parasitic mites of the honey bee and from Africanized bees moving northward from Latin America, has resulted in the establishment of research programs on queen breeding (Corner 1977) and package bees (Winston 1983) in British Columbia. The presence of one of these mite parasites, *Acarapis woodi* (Rennie), was discovered in some of the package and queen producing regions of the southern United States in 1984, and has resulted in quarantines and import restrictions being imposed on the affected areas. A ban on importations of packages from the United States would create considerable hardship for Canadian beekeepers, since New Zealand is the only other country from which bees may be imported, and it is only a minor source of packages and queens (Canadian Honey Council 1982).

The feasibility of producing package bees at competitive volumes in western Canada was first demonstrated by Pankiw and Corner (1970), and is now the subject of extensive research in British Columbia (Winston 1983; McCutcheon 1984). Development of a package bee industry would be facilitated by successful overwintering of large numbers of queens, since spring-reared queens may not be available early enough to meet the April deadlines necessary for commercial Canadian beekeeping. This study was started to investigate various methods of overwintering queens.

In the study, queens were overwintered either in a 2-frame nucleus (small populations of worker bees on 2 frames) or in a mass holding facility, as described by Harp (1969). In the nuclei, single queens are free to move over the combs; in the Harp system, many queens are confined in special compartments on a modified frame. In both systems, the queens may lay eggs. An evaluation of queens overwintered by these two methods was undertaken in April 1983.

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