SOME INFLUENCES OF AREA AND PEST MANAGEMENT ON APPLE MITE POPULATIONS IN THE OKANAGAN VALLEY OF BRITISH COLUMBIA

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Abstract

Biweekly leaf samples were taken from commercial apple orchards in four main growing areas, from north to south of the Okanagan Valley, each about 70 km apart, during the full growing season of 1983. Both phytophagous and predacious mite distribution and abundance were influenced by the area and four management practices. Unsprayed orchards had few mites whereas regularly sprayed orchards tended to have larger mite populations, the species composition and abundance of which varied with area. The numbers of some species of phytophagous mites appeared to be related to the species and abundance of predacious mites present in a given orchard.

Introduction

Integrated mite control has been practiced in apple orchards of the Okanagan and Similkameen Valleys for about 15 years (Downing and Arrand 1976). During that time miticide applications for the control of European red mite (*Panonychus ulmi,* (Koch)), McDaniel spidermite (*Tetranychus mcdanieli,* McG.) and apple rust mite (*Aculus schlectendali* (Nalepa)), have steadily decreased, probably because of the effectiveness of the various species of predacious mites, primarily in the family Phytoseiidae, which are found in many apple orchards. The frequency of insecticide application has also decreased, most notably as a result of the implementation of pest management procedures that have reduced the number of annual sprays for codling moth (*Cydia pomonella* (L)) from four or five to two or three. During this time, growers commented that the integrated mite control program appeared to be most effective toward the southern end of the growing region. It was not clear if this was a result of differences in cultural practices, grower tolerance (or intolerance) to phytophagous mites, or a biogeographical phenomenon related to predator species composition and abundance in different areas.

Previous work by Anderson and Morgan (1958), Anderson *et al.* (1958), and Downing and Moilliet (1971) suggested that of 28 to 30 species of predacious mites found in southern British Columbia, only three or four species occur in relatively large numbers and are common in commercial orchards. These authors did not report which areas of the Okanagan Valley were sampled and there is a suggestion in Anderson and Morgan (1958) that the phytoseiids did not maintain the phytophagous mite populations at acceptable levels. This conclusion may have reflected the miticidal properties of the insecticides available to growers at the time. That is, those compounds may have prevented the development of large and diverse predator populations.

This study was undertaken to determine the effects of area and thus climate, plus pest management on the species distribution and abundance of both phytophagous and predacious mites in Okanagan apple orchards.

Materials and Methods

The growing region was divided into four areas each centered on the principal town: Vernon, at the extreme north end of the growing region; Kelowna, approximately 70 km to the south; Summerland (including Penticton) a further 70 km south; and the Osoyoos-Oliver-Cawston area about the same distance south again and close to the U.S. boundary, referred to here as Oliver/Osoyoos. After discussions with packing house field persons and private pest management consultants, orchards were selected in each of the four areas and classified as abandoned, organic, integrated or traditional. Abandoned orchards usually consisted of a few trees that had not been tended for at least the previous season. No, or few, synthetic chemical sprays were applied to organic orchards, but the frequency of chemical applications in integrated orchards was limited to those occasions when a pest exceeded a pre-specified threshold. In some of the integrated orchards that we studied, this resulted in no sprays being applied for the year of the study. Traditional orchards were sprayed largely on a calendar basis without reference to the population levels of pest species present. There were at least two orchards in each classification in each region except for a single abandoned orchard in the Vernon area.

Mite populations were sampled every two weeks from mid-May to mid-August, 1983 by randomly selecting 20 leaves per tree from a minimum of 10 trees per orchard. Spur leaves were used early in the season and current year shoots later. The variety "Red Delicious" was used whenever possible. The leaves were then processed with a mite brushing machine as described in Morgan *et al.* (1955) and results were recorded and analyzed on the basis of mites/ 20 leaves. Phytophagous mites were identified to species by using a stereo microscope during the counting. Every 2nd to 5th phytoseiid predacious mite encountered on the counting plate was mounted in Hoyer's medium and identified to species using a phase-contrast compound microscope.

None of the orchards studied received a miticide application, other than dormant oil, during the season of the study.

The total number (per 20 leaves) of each species of mite found on each sampling occasion for the duration of the study was subject to a two-way Analysis of Variance (using location and pest management method as main effects) and the Least Significant Difference test (SAS, Proc GLM). Data were transformed to log (x+1) when appropriate.

Results and Discussion

Three species of phytophagous mites *(P. ulmi, A. schlectendali* and *T. mcdanieli)* were found in the leaf samples. *T. mcdanieli* was found so infrequently that it was not included in any further analyses. Four species of Phytoseiidae *(Typhlodromus occidentalis* Nesbitt, *T. caudiglans* Schuster, *T. columbiensis* Chant and *Amblyseius* sp. near *herbarius* Wainstein were found reguarly though T. columbiensis was found in only one orchard and in small numbers, and the Amblyseius sp. was very rare, occurring only in integrated control orchards in the southern half of the valley.

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Table I. Mean (± standard error) total number of European red mites per 20 leaves after the indicated number of elapsed days sampled from commercial orchards under four pest management systems in four areas of the Okanagan Valley of British Columbia in 1983.

Area	Days	Abandoned	Organic	Integrated	Traditional	Area mean	
Vernon	78	0.7/0.3	58.8/19.9	0.6/0.4	113.4/33.7	43.0/12.3	1
Kelowna	77	1.1/0.5	4.4/1.7	1.6/0.5	2.5/1.3	2.4/0.6	2
Summerland	83	0.1/0.1	0.5/0.3	18.2/6.9	4.8/2.0	5.9/2.1	2
Oliver/ Osoyoos	84	1.6/0.4	0.0	12.9/4.4	5.8/1.6	6.9/2.0	2
Mean		0.9/0.2 a	14.5/5.9 bc	9.9/2.6 bc	26.3/9.8 b		

*Means followed by the same letter or number are not significantly different (LSD, P<0.05)

The ERM population was larger in the Vernon area than in the three other areas (Table I) and populations were higher in traditional, integrated and organic orchards than in abandoned orchards (Table I). The two-way ANOVA showed a significant interaction effect for area and pest management system presumably because of the large number of ERM found in the Vernon orchards. If the Vernon area data are omitted from the analysis there are no significant area affects and the number of ERM found in integrated orchards is significantly higher than in the other 3 types ($p < 0.01$).

There were more rust mites in the Oliver/Osoyoos area than in the three more northerly areas and in traditional and organic orchards than in either abandoned or integrated orchards (Table II).

The phytoseiid population was also larger in the Oliver/Osoyoos area than in the other areas (Table III) but did not appear to differ between orchard types.

As nearly 100% of the growers in the study had applied dormant oil for ERM control at the beginning of the year, ERM population differences between orchards must be due to factors other than the use or non-use of dormant control measures. That is, dormant control using oil probably acts in a density-dependant manner. Only those eggs exposed to the oil fail to hatch, and in large populations more eggs would be in exposed situations than in small populations. Therefore we would expect similar egg survival regardless of the size of the egg population as there are only a limited number of refugia available. Differences in phytoseiid numbers and species, differences in predator efficiency resulting from species or strain differences, and differences in climate that might favour one area over the other in terms of rate of population increase or predation rate could explain differences in ERM populations between orchards. These influences may act in concert or individually at different times.

Table II. Mean (± standard error) total number of apple rust mites per 20 leaves after the indicated number of elapsed days sampled from commercial orchards under four pest management systems in four areas of the Okanagan Valley of British Columbia in 1983.

Area	Days	Abandoned	Organic	Integrated	Traditional	Area mean
Vernon	78	804.8/ 353.6	3755.7/ 1156.1	72.8/ 41.1	606.2/ 409.6	1372.5/ 434.3 1
Kelowna	77	54.3/ 25.8	2521.7/ 811.2	1063.9/ 509.8	2348.4/ 889.9	1475.3/ 358.7 1
Summerland	83	183.7/ 60.7	1089.7/ 790.6	927.7/ 433.7	2379.9/ 857.4	1189.2/ 342.1 1
Oliver/ Osoyoos	84	1892.9/ 642.5	2200.7/ 869.3	1809.9/ 413.1	6116.1/ 1735.7	2627.5/ 449.7 2
Mean		1065.4/ 333.7 a	2190.8/ 466.6 b	1210.6/ 242.6 a	3045.5/ 672.9 b	

*Means followed by the same letter or number are not significantly different (LSD, $P<0.05$)

Table III. Mean (± standard error) total number of Phytoseiids per 20 leaves after the indicated number of elapsed days sampled from commercial orchards under four pest management systems in four areas of the Okanagan Valley of British Columbia in 1983.

Area	Days	Abandoned	Organic	Integrated	Traditional	Area mean	
Vernon	78	8.0/1.9	7.0/2.4	0.0	0.5/0.3	3.4/0.9	1
Kelowna	77	1.2/0.7	1.2/0.5	2.8/0.8	10.4/2.0	4.0/0.9	1
Summerland	83	6.5/2.4	1.5/0.7	3.4/1.5	1.1/0.5	3.0/0.8	1
Oliver/ Osoyoos	84	5.7/2.1	4.2/1.3	10.5/2.0	7.4/1.7	8.1/1.1	2
Mean		5.2/1.1	3.4/0.8	6.2/1.1	4.9/1.0		

*Means followed by the same number are not significantly different (LSD, P<0.05)

Twenty-nine-year, yearly average maximum and minimum temperatures and yearly precipitation (Table IV) show that there is a cold to warm temperature gradient from north to south and a somewhat similar high to low precipitation gradient. However, the Osoyoos area is intermediate between the Vernon and the other two areas for precipitation. This suggests that mite population growth should be slower at the north end of the valley than at the south end. Temperature dependant phenomena such as phytoseiid predation rates should also be lower in the north than in the south, at least early in the season when temperature differences would be greatest. Therefore, the same number of phytoseiids should consume more prey per unit time in the south end of the valley than in the north end. This would allow a peak number of phytoseiids in the north to be associated with a larger population of ERM than a similar phytoseiid population in the south.

Table IV. Mean yearly minimum temperature, maximum temperature and rainfall (29-year average) for four areas of the Okanagan Valley of British Columbia.

Area	Minimum (C)	Maximum (C)	Rainfall (mm)
Vernon	1.8	12.6	290.4
Kelowna	2.2	13.2	221.9
Summerland	4.0	13.8	213.5
Oliver/Osoyoos	4.6	15.9	245.6

Source: Canadian Climate Normals. 1951-1980. Environment Canada.

Phytoseiid winter mortality is greater in the north than in the south. During the winter of 1985-86 phytoseiid mortality was near 100% in the Kelowna area while it was 80-85% in the Oliver area. Therefore, phytoseiid populations in the north would be lower at the start of the year, and may not be so responsive to prey population increases because of the reduced average temperatures. It is not possible to assess the applicability of this assumption with only one years data.

Although there are temperature differences between the areas, the variation between Vernon and Kelowna, for example, is probably not great enough to completely account for the differences in phytophagous mite populations found. Qualitative differences between predator populations may be important. *T. occidentalis* and *T. caudiglans* were the most abundant phytoseiids found during this survey. *T. caudiglans* comprised only 0.01% of the total predators found in the Vernon area but was found in varying numbers in the other areas. On both an area and a management system basis, *T. caudiglans* was always less abundant than *T. occidentalis* (Tables V and VI).

In abandoned orchards, *T. caudiglans* was the most abundant phytoseiid. It was almost totally absent from organic and traditional orchards, and was present in variable mumbers in integrated orchards (Table VI). This relationship was consistent in two of the three areas in which *T. caudiglans* was present; it was not found in the integrated control orchards that we studied in the Summerland area.

Table V. Percent composition by species of Phytoseiidae in commercial apple orchards in four areas of the Okanagan Valley of British Columbia in 1983.

Area	Percent composition	
	Typhlodromus caudiglans	*Typhlodromus occidentalis*
Vernon	0.01	99.9
Kelowna	24.1	75.9
Summerland	6.0	94.0
Oliver/Osoyoos	18.7	81.3

It has been reported by Downing and Moilliet (1972) that if organophosphate sprays are terminated, *T. caudiglans* will competitively displace *T. occidentalis* but if the sprays are resumed the reverse occurs. We found an apparent relationship between the relative abundance of *T. caudiglans* and the use of organophosphates (such as phosmet, phosalone, azinphosmethyl) and growing area or no organophosphate use. In effect, organophosphates essentially exclude *T. caudiglans* from orchards in the north but not in the south. *T. caudiglans* was found in 13 orchards; three in the Kelowna area, three in the Summerland area and the balance in the South End. No organophosphates were used in those orchards where it was found outside of the Oliver/Osoyoos area, while phosmet, phosalone or azinphosmethyl were used in five of the seven orchards in that area. A study is currently underway to confirm the possibility that *T. caudiglans* may have developed resistance to organophophates in the southern part of the valley. This could be important if true, because our data and those of others such as Downing and Moilliet (1972) suggest that *T. caudiglans* is superior to *T. occidentalis* for the control of ERM.

Table VI. Percent composition by species of Phytoseiidae in Okanagan (British Columbia) apple orchards subject to different pest management strategies in 1983.

Management strategy	Percent composition	
	Typhlodromus caudiglans	Typhlodromus occidentalis
Traditional	1.0	97.9
Integrated	2.6	97.4
Organic	0.2	99.8
Abandoned	52.7	47.3

Further evidence for the superiority of *T. caudiglans* as a predator comes from observations made in an orchard with a very low codling moth population that resulted from the sterile male method of codling moth control of some years earlier. The orchard presented an opportunity for comparison when it became necessary to spray one half of the orchard for codling moth control in 1984. In 1983 *T. caudiglans* made up more than 50% of the phytoseiid population in this orchard and ERM were barely detectable. In 1984, after azinphosmethyl was applied, the phytoseiid population in the unsprayed half of the orchard still consisted primarily of *T. caudiglans* and ERM were still at very low levels. But *T. caudiglans* was virtually eliminated from the sprayed half of the orchard, although *T. occidentalis* survived. ERM levels in the sprayed half exceeded economic threshold values for the first time in 6 years (Table VII).

In conclusion, it appears that different growing areas, with their associated climatic differences and pest management practices can affect the distribution and abundance of both phytophagous and predacious mites.

Table VII. Percent composition by species of Phytoseiidae (*Typhlodromus* spp.), mean number of phytoseiids/20 leaves at peak population levels and European red mite (ERM)/20 leaves at peak population levels in the Herz orchard, Cawston, B.C during 1983 and 1984.

Year	Percent composition		Numbers/20 leaves at peak levels	
	T. caudiglans	T. occidentalis	Phytoseiidae	ERM
1983 unsprayed	68.4	31.6	26.0	2.0
1984 unsprayed	97.6	2.4	8.0	3.0
1984 sprayed	0	100.00	4.0	1386.4

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EFFICACY AND RESIDUES OF CHLORPYRIFOS APPLIED AGAINST ROOT MAGGOTS ATTACKING COLE CROPS IN BRITISH COLUMBIA

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Abstract

Chlorpyrifos proved to be as effective as chlorfenvinphos, and more effective than fensulfothion and diazinon for cabbage maggot control in root and stem crucifers. For short season crops such as cauliflower, broccoli and cabbage, the granular formulation applied at seeding, followed in 21 days with a single drench of the emulsifiable liquid formulation was adequate. In Brussels sprouts, the slowest of the stem crucifers to mature, a minimum of two drench applications were necessary for acceptable control. In rutabaga, another long season crop, chlorpyrifos 15G applied at seeding followed by 3 drench applications (i.e. at 21 day intervals) after seeding was necessary to produce rutabagas with acceptable damage levels at harvest. In the sandy-clay loam where these studies were undertaken, chlorpyrifos applied at the dosage rates and at the times prescribed for the stem and root crucifers studied did not give rise to appreciable residues at harvest. These studies show that a pre-harvest interval of 32 days would be appropriate for the 5 crops studied.

Introduction

The cabbage maggot, *Delia radicum* (L.), is a chronic and serious pest of cole crops grown in the Fraser Valley and Vancouver Island regions of B.C. If not adequately controlled, maggot feeding may kill, weaken or stunt developing plants and reduce yields considerably. In root crucifers such as rutabaga and turnip, maggots can render the crop unmarketable if more than slight damage caused by their feeding is evident on the roots at harvest. Research into the biology and control of this pest pertinent to this growing region has been reported by King and