Lowering Incidence of a Virus Complex Dominated by Strawberry Mottle Virus by Reducing Numbers of the Aphid Vector with Oxydemetonmethyl

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ABSTRACT

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The efficacy of 24% oxydemetonmethyl was evaluated in relation to aphid control, strawberry yield, and virus incidence during 1987 and 1988 at Abbotsford, British Columbia. Numbers of *Chaetosiphon fragaefolii* in treated plots were significantly lower than in control plots. Yield was positively correlated and virus incidence was negatively correlated with the rate of application of oxydemetonmethyl in 1988 but not in 1987. Strawberry mottle virus was isolated from 83%, strawberry veinbanding virus from 27%, and strawberry mild yellow edge virus from 4% of the plants that tested positive for virus in 1988. The results suggest that the secondary spread of strawberry viruses may be significantly reduced by lowering aphid numbers and that nonchemical methods of vector regulation deserve greater attention for their potential in limiting virus spread.

Aphid-borne virus diseases can have a significant effect on yields of cultivated strawberry (*Fragaria* × *ananassa* Duch.) (1,2,11). Regulation of aphids on this crop is a major concern in the Pacific Northwest. Shanks (17) suggested that unless all fields in an area are sprayed for aphid control, sprays on one field will be wasted because viruliferous alates can transmit the infectious particles before the insecticide kills the vector. Converse and AliNiazee (3), however, reported that the application of oxydemetonmethyl significantly reduced the incidence of virus in a new field despite the proximity of an unsprayed field that harbored viruses and aphid vectors.

Strawberry mild yellow-edge (SMYEV) was the predominant virus observed by Converse and AliNiazee (3). An aphid must feed several days to effectively transmit SMYEV (4), but only a few minutes of feeding are required for effective transmission of other viruses, such as strawberry mottle virus (SMV) (10). One might therefore expect different results from those Converse and AliNiazee (3) reported if the virus complex was predominantly composed of SMV (13). We undertook the present study to examine the effects of oxydemetonmethyl on virus incidence in a location where the virus complex was different from that observed by Converse and AliNiazee (3).

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MATERIALS AND METHODS

A 0.11-ha field at Abbotsford, British Columbia, was prepared according to agricultural recommendations and planted on 29 April 1987 with certified Totem strawberry plants, with 0.6-m spacing within rows and 1.2-m between rows. Fifty plants were potted, fumigated, grown in a greenhouse, and indexed for viruses at a later date to determine whether the certified stock was infected at the time of planting in the field.

An experimental plot consisted of three 6.0-m rows and was separated from other plots by a guard row on the side and 3.6 m of row at either end. Three rates of 24% oxydemetonmethyl (Metasystox-R 2.4 SC)—0.14, 0.28, and 0.56 kg a.i./ha—were applied four times during 1987 (Fig. 1). These rates represented 0.5×, 1×, and 2× the U.S. recommended foliar application rate for a full crop canopy, with only one-half the volume of spray applied because the plants were small. The final spray in 1987 and two subsequent sprays in 1988 (Figs. 1 and 2) were applied at 0.28, 0.56, and 1.12 kg a.i./ha. The three treatments and a control were arranged in a randomized complete block design replicated four times within the field.

The plants were sampled for aphids every 1–4 wk from June to October in 1987 and from April to September in 1988. Fifteen young unfolding leaves were sampled from each plot during 1987 and 30 were sampled during 1988. The aphids were removed from the leaves and placed in ethanol, after which they were counted either as *Chaetosiphon fragaefolii* (Cockerell) or as "other aphids." The berries in each plot were picked, counted, and weighed from 30 June to 21 July 1987 and from 15 June to 11 July 1988.

The plants were indexed for viruses 21 July and 5 August 1987 and 25 July and 5 August 1988. In the first year, 24 of the 30 mother plants in each plot were indexed. During the second year, mother plants could not be distinguished, but 20 different crowns from each plot were indexed. Young unfolding leaves were placed into individual vials in the field and maintained at 4 C until processing in the laboratory. All the aphids were removed from the leaves, and three to six apterous, virus-free adult *C. fragaefolii* that had been maintained on *F. vesca* L. 'Baron Solemacher' were placed on each leaf. After 3–4 days, the aphids on each leaf were removed and placed on two Baron Solemacher plants that had grown to the two- to three-leaf stage. Control Baron Solemacher plants having either no *C. fragaefolii* or virus-free *C. fragaefolii* were dispersed among the test plants. All the plants were fumigated with methyl bromide 3–5 days later and were then placed in the greenhouse. After 2–3 wk, the plants were examined for virus symptoms (2) every 4–7 days for 6–7 wk.

RESULTS

Aphid numbers over the 2-yr period were significantly higher in the controls than in treated plots ($P < 0.001$), although aphid numbers in treated plots increased during periods when oxydemetonmethyl was not applied (Figs. 1 and 2). The most rapid increase in aphid numbers occurred in the spring of 1987 after the application of three sprays. There were, however, 4.9 ± 0.14 leaves per plant 3 days before the third spray, so only a small portion of the applied pesticide contacted the plant, and this was probably rapidly diluted by plant growth. Yields were not significantly different in 1987 but were positively correlated ($P < 0.01$) with the application rate of oxydemetonmethyl in 1988 (Fig. 3).

Virus indexing during 1987, 12 wk after planting, indicated that 17% of the parent plants were infected with viruses and that there was no correlation with the pesticide application rate. SMV, strawberry veinbanding virus (SVBV), and SMYEV were isolated from 61, 2, and 2 plants, respectively; one additional

plant was infected with SMV and SVBV. Some of these plants may have been infected before being planted, because three of the 50 original certified Totem crowns grown in the greenhouse were infected with SMV. Virus indexing during 1988 suggested that the number of crowns infected with virus in the 16 plots ranged from 65 to 95%. The proportion of infected plants was negatively correlated ($P < 0.01$) with the pesticide application rate (Fig. 4). Viruses were isolated in 249 of the 312 crowns indexed: SMV alone in 138, SVBV alone in 43, SMV and SVBV in 59, and SMV, SVBV, and SMYEV in 9.

DISCUSSION

Virus infection in each plot came from a number of sources: about 6% from the original planting stock, about 11% (virus indexing August 1987) from viruliferous alate aphids from other fields (16), and about 63% (virus indexing August 1988) from a combination of the latter and within-plot (6) and between-plot (15) movement.

Given the proximity of treated plots to controls, as well as the prevalence of SMV, which is rapidly acquired and transmitted, one might have expected the proportion of infected plants in the experimental plots to equal that in the controls. However, the application of oxydemetonmethyl resulted in reduced virus incidence. Pesticides that act quickly (8) or have a repellent effect (12) can influence the introduction of viruses by immigrant alates, but oxydemeton-methyl probably does not possess these qualities once it is absorbed by the plant. Five hours of feeding were required for 90% mortality of alate *C. fragaefolii* 3 days after treatment of foliage with a 0.063% emulsion of oxydemetonmethyl (15). Experiments that simulated the immigration of *Myzus persicae* (Sulzer) into a field after a spray showed that demeton-S-methyl, a chemical that is rapidly absorbed by plant tissue and metabolized to oxydemetonmethyl (7,9), had no repellent effect (12). Therefore, the application of oxydemetonmethyl probably did not influence the transmission of SMV or SVBV by immigrant aphids.

Oxydemetonmethyl did reduce aphid numbers. A reduction in the number of apterae moving within a row (6) could affect the probability of within-row spread of viruses and account for the negative relationship between virus incidence and the application rate of oxydemetonmethyl. A possible mechanism for within-row movement of *C. fragaefolii* is a reduction in preference for fully expanded leaves (6). We have observed that *C. fragaefolii* is usually found on young unfolding leaves and that these leaves are produced and become mature at a constant rate of 0.097 ± 0.00492 per day from June to September inclusive, about one leaf every 10 days (*unpublished*). These observations therefore concur with those of Dicker (6) but not with those of Converse et al (5), who found evidence that SMYEV infections occurred primarily by means of alate aphids. The different results may have been a function of the planting systems used in these studies. Matted-rows provided a runner network for aphid movement between plants in the present study. Converse et al (5) used the hill system, in which runners were controlled. Dicker (6) worked with plants spaced at 0.46 m but made no mention of runner control. Behavioral studies within the different planting systems are necessary to clarify the role of aphid movement.

Shanks (15) stated: "Very low numbers of aphids may inoculate large numbers of plants, so aphid control must be virtually perfect." Perfect control, however, is probably not possible with pesticides (14), and the present study suggests that for local conditions, at least, perfect control may not be required to obtain production benefits. In situations where secondary spread is an important part of the virus epidemiology, any method of reducing aphid numbers, provided it does not stimulate aphid movement, should reduce the probability

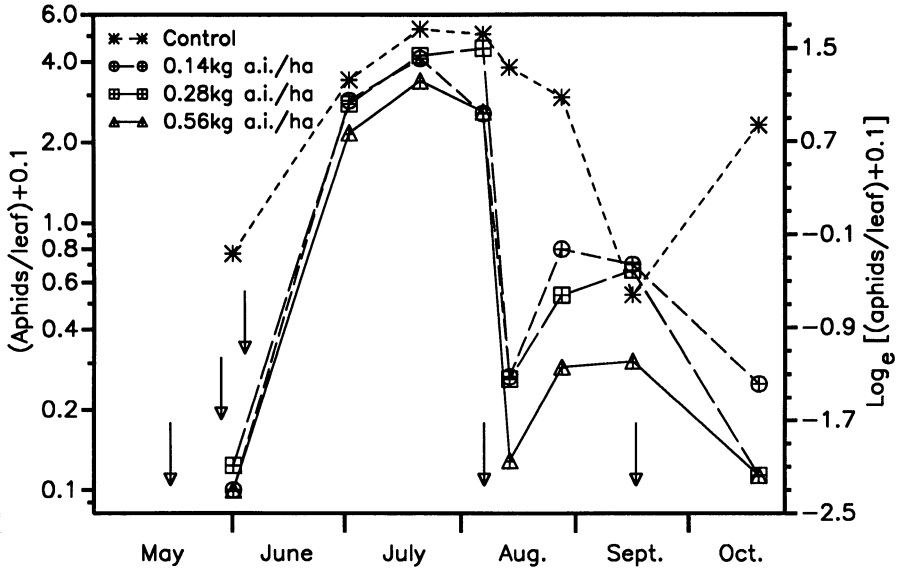

Fig. 1. Population trends of *Chaetosiphon fragaefolii* on *Fragaria* × *ananassa* 'Totem' during the planting year, 1987. Vertical arrows indicate the dates of application of oxydemetonmethyl. The legend applies to the first four sprays; the final spray was applied at double each indicated rate. One standard error of the mean, read on the right vertical scale, was ±0.1669.

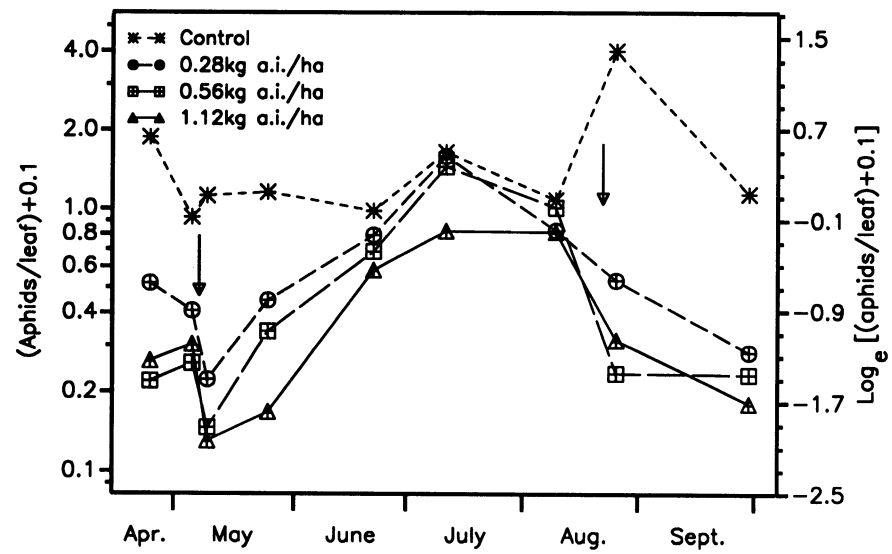

Fig. 2. Population trends of *Chaetosiphon fragaefolii* on *Fragaria* × *ananassa* 'Totem' during 1988. Vertical arrows indicate the dates of application of oxydemetonmethyl. One standard error of the mean, read on the right vertical scale, was ±0.2135.

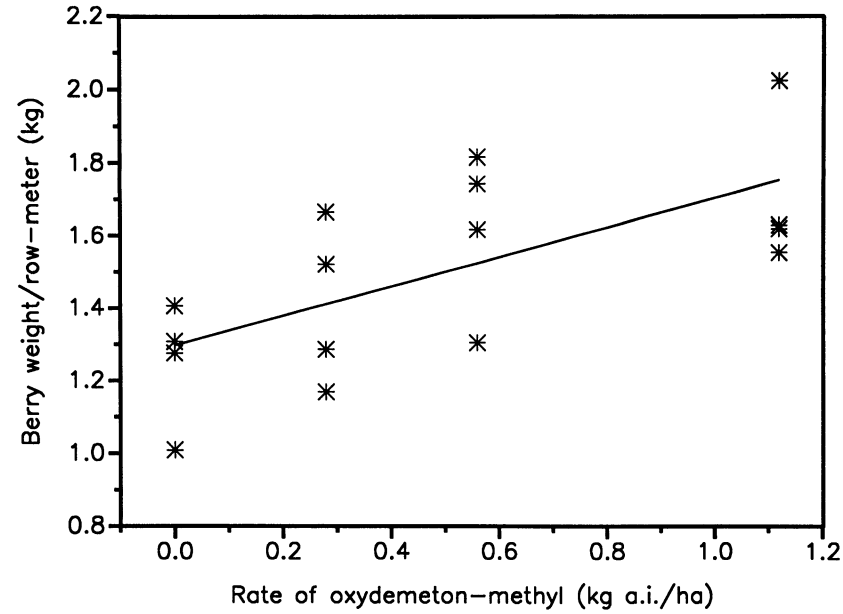

Fig. 3. Strawberry yield as a function of the rate of application of oxydemetonmethyl ($Y = 1.30 + 0.407\ X$; $F = 10.9$; $r = 0.662$; 14 df). Average yields (kg/row-meter) for increasing spray rates were: 1.25 a, 1.41 ab, 1.62 b, and 1.71 b (means followed by the same letter are not significantly different [$P > 0.05$] according to Duncan's test). One standard error of an average yield was ±0.100.

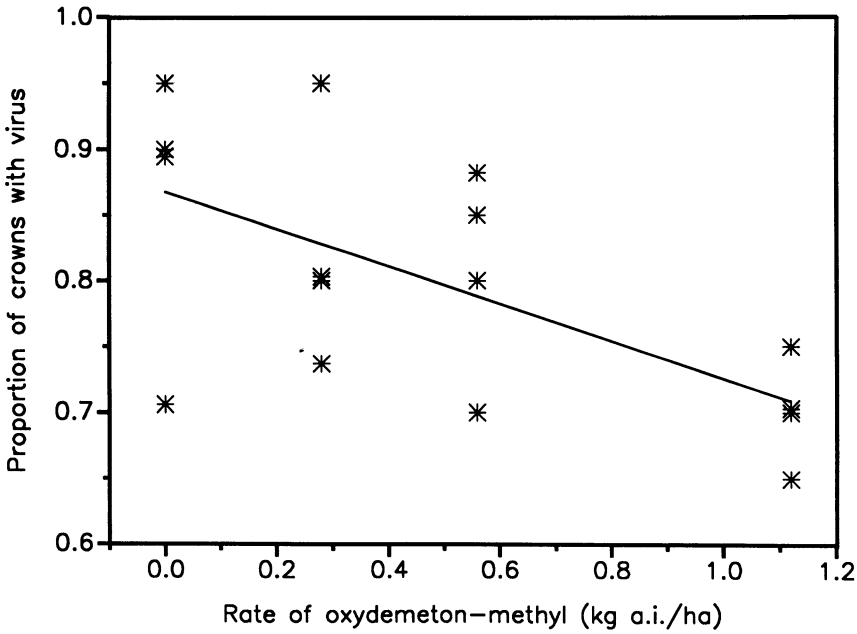

Fig. 4. Virus incidence as a function of the rate of application of oxydemetonmethyl ($Y = 0.868 - 0.142\ X$; $F = 9.12$; $r = -0.628$, 14 df).

of infected aphids moving to uninfected plants. The potential of alternate methods of vector regulation has not been intensively examined in the context of the secondary spread of viruses. Given the current trend toward reduced pesticide use in agricultural systems, such methods as biological control and plant breeding deserve greater attention.

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