The Great Lakes Entomologist

Volume 20
Number 2 - Summer 1987 *Number 2 - Summer 1987*

Article 11

June 1987

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Recommended Citation

Setiawan, Dwi P. and Ragsdale, David W. 1987. "Use of Aluminum-Foil and Oat-Straw Mulches for Controlling Aster Leafhopper, *Macrosteles Fascifrons* (Homoptera: Cicadellidae), and Aster Yellows in Carrots.," *The Great Lakes Entomologist*, vol 20 (2)
DOI: https://doi.org/10.22543/0090-0222.1605
Available at: https://scholar.valpo.edu/tgle/vol20/iss2/11

USE OF ALUMINUM-FOIL AND OAT-STRAW MULCHES FOR CONTROLLING ASTER LEAFHOPPER, *MACROSTELES FASCIFRONS* (HOMOPTERA: CICADELLIDAE), AND ASTER YELLOWS IN CARROTS.

Dwi P. Setiawan[1] and David W. Ragsdale[2]

ABSTRACT

Aluminum-foil and oat-straw mulches significantly ($P < 0.05$) reduced aster leafhopper numbers on carrots compared to an untreated control and a malathion spray treatment during the first half of the growing season. The amount of reflected light was significantly higher in both aluminum-foil and oat-straw mulched plots compared to unmulched treatments. Mulch effectiveness decreased when the closing carrot canopy reduced surface area of reflective mulches and amount of reflected light. The percentage of aster yellows-infected plants was significantly lower ($P < 0.05$) in aluminum-foil and straw mulches and in the malathion spray plots compared to the untreated control. Results demonstrated that aluminum-foil and straw mulches gave control of aster leafhoppers and aster yellows in carrots equal to that of a conventional insecticide spray program.

Aster yellows is an important insect-vectored disease of many vegetables, ornamentals, and grasses (Wallis 1960). Severe damage to carrots by aster yellows has been frequently reported (Whipple et al. 1940, Knight and Blodgett 1945, Ivanoff and Ewart 1944, Chapman 1973). In Minnesota, aster yellows is a key factor limiting production of lettuce, carrots and celery (Zalom 1981).

Aster yellows is transmitted and distributed principally by the aster leafhopper, *Macrosteles fascifrons* (Stal). Although the aster leafhopper can overwinter in the egg stage, migrants from the southern and central U.S. are most important in terms of numbers and as a source of the aster yellows pathogen (Chiykowski and Chapman 1956, 1965; Chapman 1973; Drake and Chapman 1965; Peterson 1973).

Reflective mulches such as aluminum foil and colored plastic mulches have been shown to be effective in controlling virus diseases in various crops such as sugar beets, cucumbers, tomatoes, peppers, and watermelons (Jones and Chapman 1968, Lobenstein et al. 1975, Daiber and Donaldson 1976) by reducing the number of insect vectors or by making the habitat less suitable for the insect (Cohen 1984). Recently, Cardona et al. (1981) demonstrated that rice-straw mulch gave effective control of the leafhopper *Empoasca kraemeri* Ross in dry beans. Zalom (1981) demonstrated that aluminum-foil mulch gave effective control of the aster leafhopper and aster yellows in head lettuce in Minnesota.

Objectives of this study were to compare efficacy of aluminum-foil and oat-straw mulches to a conventional malathion spray program for control of aster leafhopper and aster yellows in carrots.

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MATERIALS AND METHODS

The experiment was conducted at the University of Minnesota Agricultural Experiment Station, Rosemount, Minnesota. In 1985, an aster yellows-susceptible carrot variety, 'Danvers 126,' was planted in rows 0.62 m apart. Each plot consisted of nine rows, 5.5 m long with a 10-row border between replications and a 5.5-m border between treatments. Borders were untreated.

Treatments were aluminum-foil covered paper (Al-foil) mulch, oat-straw mulch, weekly application of malathion spray (1.68 kg AI/ha), and an untreated control. Al-foil and straw mulches were laid between rows of carrots at the 2–4 leaf stage. Malathion was chosen from recommendations in Waters et al. (1981). A randomized complete block design with four replications was used.

Sampling aster leafhoppers was done with both sweepnet and green-colored sticky traps. Twenty pendulum sweeps were used as the sweepnet sampling unit. Sticky traps were a modification of the trap designed by Irwin (1980) who used them for measuring aphid landing rates on a soybean canopy. Preliminary sampling experiments of aster leafhoppers in carrots showed green-tile traps not as attractive as yellow traps. However, yellow traps are known to be attractive to aster leafhoppers, and we hypothesized that such traps might mask differences among treatments in leafhopper counts by attracting insects from untreated borders. Green colored tiles (Cambridge #815) closely mimicked the reflectance spectrum of carrot foliage and were placed vertically in the center of each plot and covered with diluted Stickem Special®. A single trap consisted of two tiles back to back, clamped to a metal pole and placed at canopy height. Traps were changed twice each week. Observations on plant growth and disease incidence (foliar symptoms) were made twice a week. Ten plants were chosen at random in each plot and top height was measured. The number of aster yellows-infected and healthy carrots in one random row-meter were counted. Percent reflected light was measured using a Barnes Modular Multiban Radiometer (MMR Model 12-1000). This instrument measured the percentage of light reflectance 3.5 m above the soil surface.

RESULTS AND DISCUSSION

Aluminum-foil and oat-straw mulches were effective in reducing the number of aster leafhoppers for the first half of the growing season. From 19 July to 6 August, the number of aster leafhoppers caught with green-tile sticky traps in aluminum-foil and straw mulched plots was significantly lower ($P < 0.05$) than in the malathion treated and untreated control plot. For these sampling dates, there were no significant differences in the number of aster leafhoppers caught on the green-tile sticky traps between aluminum-foil and oat-straw mulched plots. For the remainder of the season, there were no significant differences among treatments (Fig. 1a).

Sweep sampling showed trends similar to the sticky traps. From 19–30 July there were significantly more leafhoppers in the untreated control and malathion spray plots than in the mulch treatments. As the season progressed, the number of aster leafhoppers declined and few differences in leafhopper numbers were seen among treatments except for a lower number of leafhoppers by sweep sampling in malathion spray plots.

At harvest maturity (27 August), the amount of aster yellows infection in aluminum-foil, straw mulch and malathion spray plots was significantly lower than the untreated control ($P < 0.05$) (Table 1). Results of a similar field experiment conducted in 1984 (data not presented) showed the same trends. It is known that aster yellows-inoculated carrots will exhibit symptoms two or three weeks after inoculation, and that symptom expression is temperature dependent with cooler temperatures prolonging symptom development (Chapman 1973). Thus the number of aster yellows- infected carrots on each observation date is an estimate of cumulative infections from inoculations three weeks

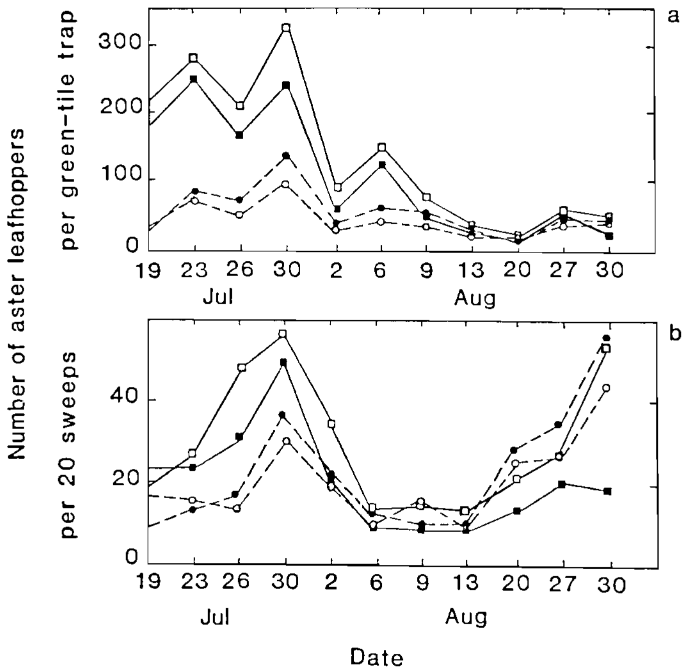

Fig. 1. Mean number of aster leafhoppers caught on the green-tile sticky traps (1a) and in 20 sweeps (1b) on each observation date: ●—aluminum-foil, ○—oat-straw mulch, ■—malathion, □—untreated check.

prior to symptom expression. However, infection levels did not continue to rise as anticipated. This may be explained, in part, by use of foliar symptoms as a measure of infection which excluded plants which apparently died of aster yellows. Linear regression analysis was used to test relationship between percent of aster yellows infection on given observation dates with the average number of aster leafhoppers three weeks prior to that. Results showed a significant ($P < 0.05$) but weak correlation between incidence of aster yellows and number of aster leafhoppers caught on green-tile sticky traps (Figure 2a.) and by sweep sampling (Figure 2b.).

Decrease in mulch effectiveness was measured by correlating plant height and number of aster leafhoppers as estimated by the two sampling methods. The ratio of aster leafhoppers caught in each treatment to the total captured on each observation date was used to minimize effects of fluctuations in aster leafhopper density. The proportion of total leafhoppers caught in aluminum-foil and straw mulch plots increased continually as carrot height increased. Both mulches became less effective as the surface area was reduced by the closing carrot canopy and as contamination from dirt and decayed plant materials reduced the amount of reflected light (Table 1). The oat-straw gradually turned from a bright straw-yellow to a dull brown because of decomposition and became less effective in repelling leafhoppers.

Table 1. Percent of aster yellows-infected carrots per meter.

Observation dates	Treatment[a]			
	Aluminum-foil	Oat-Straw	Malathion	Untreated
26 July	2.9 A	2.5 A	2.1 A	4.8 A
30 July	3.9 B	4.7 B	8.1 AB	9.2 A
2 Aug.	4.4 A	5.0 A	6.5 A	9.9 A
6 Aug.	7.9 A	5.4 A	5.9 A	9.6 A
9 Aug.	6.7 B	7.4 B	11.2 AB	14.6 A
13 Aug.	6.4 B	5.6 B	9.9 AB	14.4 A
20 Aug.	8.7 B	5.7 B	8.6 AB	14.4 A
27 Aug.	6.7 B	8.1 B	10.2 B	14.3 A
Overall Mean	6.0 B	5.6 B	7.8 B	11.4 A

[a]Means within a row followed by the same letter are not significantly different using Duncan's multiple range test ($P < 0.05$).

In monitoring reflected light, seven discrete wavelength bands were available for analysis (0.45–0.52, 0.52–0.60, 0.63–0.69, 0.76–0.90, 1.15–1.30, 1.55–1.75 and 2.08–2.35 μm). Aluminum-foil mulched plots consistently reflected more light than other plots. The amount of reflected light in the oat-straw mulch was intermediate between aluminum-foil and the unmulched treatments. The wavelength of reflected light that relates to insect vision is generally from 0.35–0.60 μm (Chapman 1982). In this experiment, wavelengths of 0.45–0.50 and 0.52–0.60 μm were the bands most likely affecting the aster leafhopper (Table 2).

The amount of reflected light in the 0.45–0.60 μm range was significantly correlated ($P < 0.05$) with the number of aster leafhoppers in the plots; i.e., as the amount of reflected light increased as in the aluminum-foil and straw mulched plots, fewer aster leafhoppers were caught ($r = -0.51$ and -0.56, respectively). Although there were significant correlations between the amount of reflected light, leafhopper abundance, and the significantly lower disease incidence in mulched plots than in the untreated check, this does not mean there was a direct cause and effect relationship. This experiment was not designed to determine the mechanism of mulch effectiveness.

The higher disease incidence that occurred in malathion spray plots than in mulch treatments (Table 1) was likely an artifact of the experimental design since only 3.6% of the 0.34-ha field was treated with an insecticide. Thus a relatively large population of leafhoppers was available to recolonize the sprayed plots as the insecticide lost effectiveness. Altogether, aluminum-foil and straw mulches gave a level of control of aster yellows equivalent to a standard insecticide spray program. Furthermore, use of an oat-straw mulch for control of aster yellows is more likely to be adopted than an aluminum-foil mulch.

ACKNOWLEDGMENTS

We would like to thank Dr. Mark Seeley and Craig Schrader, Department of Soil Science, University of Minnesota, for taking the reflectance spectrum data. This article is Paper No. 15,089 of the Minnesota Agricultural Experiment Station on research under Minnesota Agricultural Experiment Station Project No. 17-48.

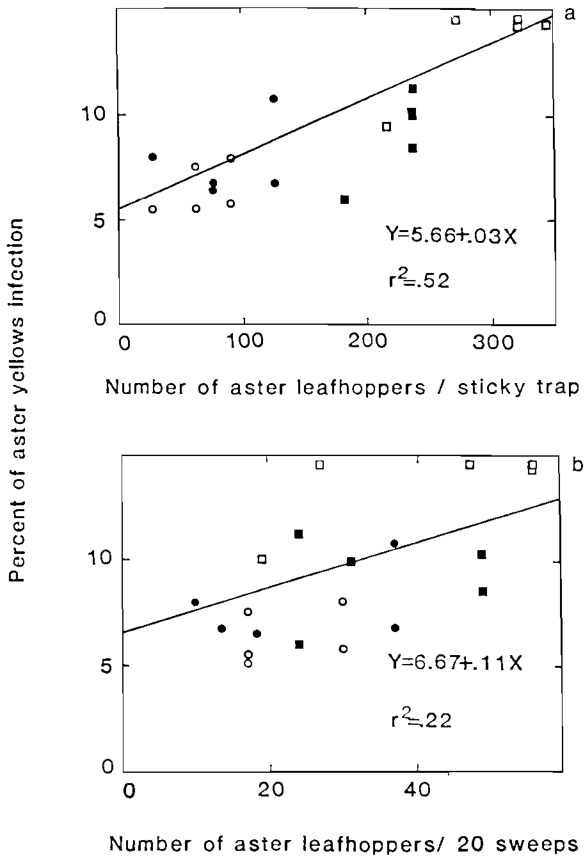

Fig. 2. Relationship between the mean number of aster leafhoppers caught on green-tile sticky traps (2a) and with sweepnet sampling (2b) with the mean percent aster yellows infection. ●—aluminum-foil, ○—oat-straw mulch, ■—malathion, □—untreated check

Table 2. Percent of reflected light in discrete wavelength bands in each treatment for each observation date.

Dates & Treatments	Wavelength (μm)[a]		
	0.45–0.52	0.52–0.60	0.63–0.69
23 July			
Aluminum-foil mulch	34.4 A	34.6 A	32.6 A
Oat-straw mulch	10.2 B	15.4 B	21.3 B
Treatments without mulch[b]	6.4 B	8.6 C	10.0 C
26 July			
Aluminum-foil mulch	50.5 A	53.3 A	52.0 A
Oat-straw mulch	13.7 B	20.6 B	27.2 B
Treatments without mulch[b]	4.7 C	7.0 C	6.9 C
1 Aug.			
Aluminum-foil mulch	21.4 A	23.3 A	22.1 A
Oat-straw mulch	7.0 B	10.7 AB	12.3 AB
Treatments without mulch[b]	7.8 B	10.0 AB	9.8 B
7 Aug.			
Aluminum-foil mulch	16.7 A	19.0 A	16.7 A
Oat-straw mulch	5.7 B	8.9 B	9.4 B
Treatments without mulch[b]	3.9 B	6.1 B	5.1 B

[a]Means within a column on one observation date followed by the same letter are not significantly different using Duncan's multiple range test ($P < 0.05$).
[b]Mean reflectance of malathion and untreated check plots.

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PUBLICATION DATE

Volume 19, Number 4 25 February 1987

COVER ILLUSTRATION

Orthotomicus caelatus (Eichhoff) (Coleoptera: Scolytidae). Drawing by Dr. Mark A Deyrup, Archbold Research Station.

DOI: 10.22543/0090-0222.1605