Aluminum-Surfaced Mulch: An Approach to the Control of Tomato Spotted Wilt Virus in Solanaceous Crops

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ABSTRACT

Greenough, D. R., Black, L. L., and Bond, W. P. 1990. Aluminum-surfaced mulch: An approach to the control of tomato spotted wilt virus in solanaceous crops. Plant Dis. 74:805-808.

The effect of plastic film mulches on thrips immigration and tomato spotted wilt virus (TSWV) incidence in tomato, pepper, and tobacco fields was studied. Three treatments (aluminum-surfaced plastic mulch, black plastic mulch, and a nonmulched control) were arranged in a randomized complete block design in each of three separate crop fields. Thrips immigration into treatment plots was estimated with the use of yellow sticky board traps. Compared with the nonmulched treatment, aluminum-surfaced mulch reduced the numbers of trapped thrips by 68% and the incidence of TSWV by 64% in tomato. In bell pepper, thrips numbers and TSWV incidence were reduced by 60% and 78%, respectively. At a second location, the number of thrips trapped was reduced 33% by the aluminum-surfaced mulch and TSWV incidence was reduced by 60% in a combined planting of tomato, pepper, and tobacco in each treatment plot. Several thrips species were identified from traps, including two known TSWV vectors, *Thrips tabaci* and *Frankliniella fusca*.

Tomato spotted wilt virus (TSWV) is a serious problem of solanaceous crops in Louisiana, causing a wide range of symptoms including chlorotic and necrotic ringspots, stem necrosis, mosaic and distortion of young leaves, chlorotic and necrotic ringspots on fruit, reduction in fruit set, and severe plant stunting. The disease was first identified in Louisiana in 1972 (3) and causes severe losses in tomato, pepper, and tobacco (6,10). Surveys have shown that TSWV incidence in tomato occasionally reaches 60% in commercial fields and 100% in home gardens (10).

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Approved for publication by the director of the Louisiana Agricultural Experiment Station as manuscript 90-38-4043.

Portion of thesis by the first author submitted in partial fulfillment of the requirements for the M.S. degree, Louisiana State University.

Accepted for publication 23 April 1990.

TSWV is vectored by Thysanoptera species (2,8,18). Two reported vectors known to occur in Louisiana (17,20), *Thrips tabaci* (Lind.) and *Frankliniella fusca* (Hinds), have been assumed to be the vectors for TSWV in this area. During the time of this investigation, *F. occidentalis* (Pergande), also a known vector for TSWV, was identified from Louisiana cotton fields (10).

No practical control measures for TSWV are currently available to the producers of field-grown solanaceous crops. Considerable effort has been expended over the past 50 yr to develop TSWV-resistant tomatoes, but in spite of the effort there is no widely accepted resistant cultivar available (2,8,9,11,18). The use of insecticides to reduce virus incidence by vector control in and around the crop fields has, in general, met with little or no success (2,7). Previous works (1,4,5,14,16,19,21) have shown that an aluminum-surfaced film mulch reduces the numbers of alate aphids that alight on plants growing above a reflective mulch, thereby reducing the incidence of aphid-borne virus diseases in certain field-grown vegetables. The repellent nature of the aluminum-surfaced mulch to aphids is thought to be associated with the light quality being reflected by the mulch (12,19,21). Thrips also are color-sensitive (13,15,23), therefore, it was thought they might respond to a reflective mulch. In a preliminary study in tomato and bell pepper fields during the spring of 1983, TSWV incidence was lower in plants and fewer thrips were trapped over aluminum-surfaced mulch than over black mulch or bare soil (D. R. Greenough and L. L. Black, *unpublished*). The present study was conducted in 1984 to evaluate the effectiveness of an aluminum-surfaced film mulch to reduce thrips immigration into tomato, pepper, and tobacco fields and thereby reduce the incidence of TSWV in those crops.

MATERIALS AND METHODS

Field plot design. Three separate tests were conducted on commercial vegetable farms in the spring of 1984. Each test was arranged in a randomized complete block design with four replications for each of the three treatments: aluminum-surfaced plastic row mulch, black plastic row mulch, and nonmulched control rows. In Point Coupee Parish, 6-wk-old plants of Jet Star tomato and Bell Boy bell pepper were transplanted into separate fields on 22 March and 20 April, respectively. Tomato plants were spaced 0.5 m apart in the row, and each replication consisted of three adjacent rows 34 m in length with three unplanted, bare rows between each replication. Pepper plants were spaced 0.38 m apart in the row, and each replication consisted of five adjacent rows 11.6 m in length. At the St. James Parish location, each treatment replication was 13.7 m in length and 15 rows in width and consisted of five rows of Perique tobacco, seven rows of Pip bell pepper, and three rows of Supersonic tomato. Within rows, tomato plants were spaced 0.5 m apart, peppers 0.38 m apart, and tobacco 0.76 m apart. Six- to eight-week-old tomato and pepper plants were transplanted on 20 March and tobacco plants on 10 April.

Plant bed preparation. Plantings were made on rows 1.2 m apart that were shaped into 20-cm-high raised beds with a 0.5-m-wide top. Rows were fumigated 2–3 wk before planting with Terr-O-Gas 67 (67% methyl bromide and 33% chloropicrin; Great Lakes Chemical Corp, West Lafayette, IN) at the rate of 170 kg/ha (equivalent to 404 kg/ha broadcast). The fumigant was injected 20 cm deep into the rows with a single chisel attached to a commercial-type film mulch layer that immediately covered the beds with a 0.038 mm (1.5 mil) thick black plastic film. To achieve an aluminum surface on the plastic mulch, a mineral spirits-based aluminum paint was applied to black plastic with a tractor PTO-driven pump spray system as the plastic was being laid in the field. The black mulch surface was unpainted black plastic film. Nonmulched rows were fumigated and covered with the plastic film as in the previous two treatments, but the plastic film was removed before planting. Fertilizer at the rate of 673 kg/ha of 12-12-12 was incorporated into the raised beds before fumigation and mulching. Crops were side-dressed once at early fruit set with 33.6 kg/ha of nitrogen by broadcasting the fertilizer between the rows and incorporating it by shallow cultivation. Trifluralin (Treflan 2E) was applied at the rate of 0.56 kg/ha to the bed tops just before laying the plastic mulch and 1.12 kg/ha to the row middles where it was immediately incorporated by shallow cultivation.

Thrips traps. Yellow sticky board traps were used to estimate thrips immigration into the test plots. The sticky boards were 30.5 × 30.5 cm squares made of 0.41-mm-thick (16 gauge) aluminum-alloy sheet metal that were painted yellow (Chem-O-Pon II, industrial epoxy coating, No. 573 safety yellow & No. 588 catalyst; Jones Blair Paint Co., Dallas, TX) on one surface. A thin layer of sticky film (Stikem Special; Seabright Enterprises, Emoryville, CA) was applied to the painted side, and the boards were suspended on a wooden post approximately 30.5 cm above the row surface with the yellow sticky side facing upward. A single trap was placed near the middle of the center row of each treatment replication. Traps were changed weekly and thrips numbers were estimated by counting four separate 2.5-cm^2 sections of each board. Representative thrips were removed from the boards, washed in varsol to dissolve Stikem residue, and stored in vials containing AGA preservative (10 parts 60% ethanol, one part glycerin, one part acetic acid). Thrips species identifications were made by L. D. Newsom and R. N. Story of the Department of Entomology, Louisiana State University.

TSWV incidence. All plants in each treatment plot were examined at 1- or 2-wk intervals from March to June and plants showing symptoms of TSWV infection were flagged and counted. Leaf tissue samples from symptomatic plants were routinely collected and assayed for TSWV in a selected host range and with agar double-diffusion serological tests (2,8,22) to confirm TSWV infections. Antiserum used in the study was provided by Tsakiridis and Gooding (22).

RESULTS

Thrips identification. Thrips identified from traps during the investigation were *F. tritici* (Fitch), *F. fusca*, *Thrips tabaci*, *F. cephalica* (Crawford), *Microcephalothrips* spp., and *Sericothrips* spp.

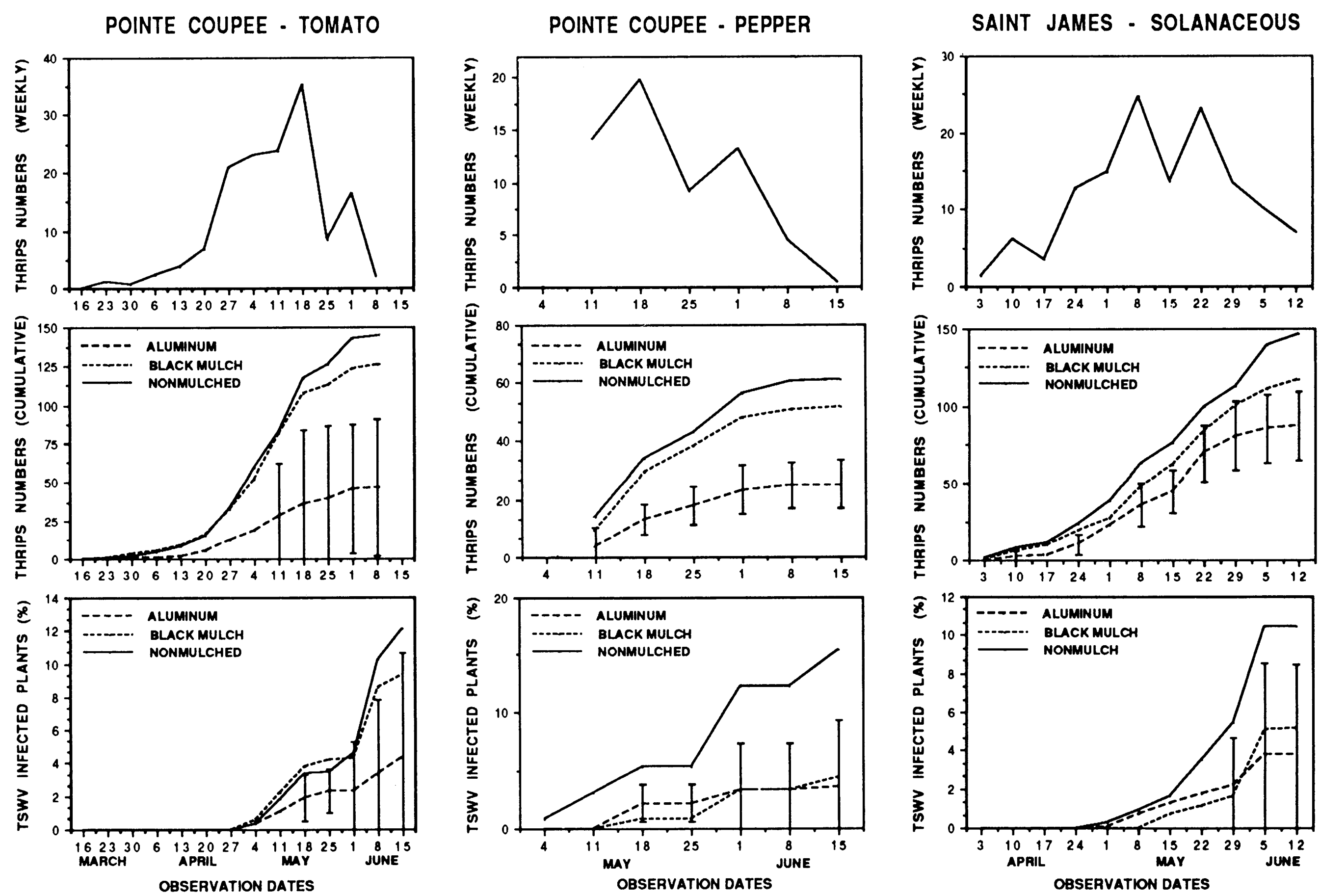

Fig. 1. Influx of thrips and incidence of TSWV-infected crop plants affected by film mulches during the spring of 1984. Pointe Coupee-Tomato and Point Coupee-Pepper data were obtained from different fields on the same farm in Point Coupee Parish. Saint James-Solanaceous data were obtained from a single field in Saint James Parish with a mixed planting of tobacco, bell pepper, and tomato. Each data point is the mean value from four replications of each treatment. Thrips numbers are counts from four 2.5-cm^2 areas on each 30.5-cm^2 yellow sticky board. TSWV incidence is the percentage of infected plants based on a minimum of 150 plants per replication. Vertical bars represent the LSD ($P = 0.05$) on each sampling date.

Frankliniella tritici and *F. fusca* were the species most abundant in the samples collected for identification from the yellow sticky traps. Although *F. occidentalis*, a known vector of TSWV, was recently identified in Louisiana (L. D. Newsom and R. N. Story, *personal communication*), it was not identified in any of the samples collected during this study.

Pointe Coupee location. Low numbers of thrips were trapped in the tomato field up to and including the 20 April observation (Fig. 1). Thereafter, there was a dramatic increase in numbers of thrips trapped with the greatest numbers being found on the traps collected on 18 May. Cumulative numbers of thrips trapped in the aluminum-mulched rows from 11 May through 8 June were significantly less than those trapped in either the black-mulched or nonmulched rows. There was no significant difference between the numbers of thrips trapped above black-mulched and nonmulched rows.

The first tomato plants exhibiting TSWV symptoms were detected on 4 May, 6 wk after being transplanted into the field, and there was an increase in the number of plants showing TSWV symptoms over the next 6 wk (Fig. 1). The increase in TSWV incidence in general trailed the increase in thrips numbers by about 1–2 wk (Fig. 1). The mean percentages of symptomatic TSWV-infected tomato plants at the conclusion of the experiment on 15 June were 12%, 9%, and 4% in the nonmulched, black-mulched, and aluminum-mulched treatment plots, respectively. There was no significant difference in the incidence of TSWV in the nonmulched and black-mulched treatments at any of the observation intervals. However, TSWV incidence in the aluminum-mulched rows was significantly lower on 18 May and on subsequent observation dates.

In the pepper field, thrips numbers were high during the first week of trapping, 4–11 May, and remained high through 1 June (Fig. 1). The highest numbers of thrips trapped during a single trapping period occurred from 11 to 18 May. The greatest numbers of thrips were trapped in the nonmulched rows and the lowest numbers in the aluminum-mulched rows; the numbers trapped in the black-mulched rows were intermediate to the other two treatments. Significantly fewer thrips were trapped in the aluminum-mulched plots compared with the nonmulched plots beginning 11 May, and significant differences were noted among all three treatments beginning 8 June.

Pepper plants with TSWV symptoms were first detected on 4 May, within 2 wk of the transplant date (Fig. 1). The highest percentage of infected plants occurred in the nonmulched plots with infection reaching about 15% on 15 June. Plants in the aluminum- and black-mulched treatments were about 3% and 4% infected, respectively, on the same date. TSWV incidence in the aluminum- and black-mulched plots was not significantly different, but both were significantly lower than the incidence in nonmulched plots.

St. James location. Numbers of thrips trapped in the mixed planting of tomato, pepper, and tobacco increased sharply during mid-April and the numbers remained high until late May (Fig. 1). The greatest numbers of thrips were trapped in the nonmulched rows, but there was no significant difference between the total numbers trapped in the nonmulched and black-mulched rows. Cumulative numbers of thrips trapped in the aluminum-mulched rows were significantly lower than those trapped in nonmulched on all trapping dates beginning 24 April and lower than those trapped in black-mulched rows on about half of the trapping dates.

Combined data for the three crops show that a sharp rise in TSWV incidence occurred about 2 wk after a large migration of thrips into the plots (Fig. 1). Virus disease symptoms were first observed in tomato and pepper plants in the St. James field on 1 May, but the major increases in the numbers of plants exhibiting TSWV symptoms were noted in all crops during the 15 May through 5 June observations (Fig. 1). TSWV incidence reached about 10% on 5 June in the nonmulched rows. By comparison, there was a significantly lower incidence of TSWV-infected plants in both the black- and aluminum-mulched rows that were about 5% and 4% infected, respectively (Fig. 1). The highest incidence of TSWV occurred in tobacco with about 18% infection in the nonmulched rows on 12 June. On the same date, nonmulched tomato and pepper plants were about 6% and 7% TSWV-infected, respectively.

DISCUSSION

Differences in the numbers of thrips trapped and the increase in numbers of TSWV-infected plants among the mulch treatments frequently were too small to be statistically significant when compared each week, but cumulative values generally showed differences among treatments. Cumulative numbers of thrips trapped and TSWV-infected plants were plotted to better express the seasonal exposure of the crops to thrips and the time course increase in TSWV incidence.

The use of an aluminum-surfaced plastic film mulch as a row surface covering in the production of tomato, bell pepper, and tobacco reduced the immigration of thrips and the incidence of TSWV in those crops. Results of more recent similar studies in tomato and bell pepper fields further substantiate these conclusions (L. L. Black and R. N. Story, *unpublished*). In the study reported here, the rise in TSWV incidence in the crop plants trailed by 1–2 wk the rise in the numbers of thrips trapped. This time period corresponds well with the expected delay in symptom expression in plants following infection with TSWV (2,18). The positive relationship between reduced thrips numbers and lower TSWV incidence in the aluminum-surfaced plots, coupled with the assumption that TSWV is transmitted only by thrips (2,8,18), strongly suggests that the reduction in thrips numbers is directly responsible for the reduction in TSWV incidence in crops grown above the aluminum-surfaced mulch. Black plastic mulch has a similar effect, but it is not as efficient as the aluminum-surfaced mulch in reducing thrips numbers or TSWV incidence.

The effectiveness of the aluminum-surfaced mulch treatment in reducing the incidence of TSWV is apparently attributable to its repellent effect on the potential TSWV vectors that would ordinarily visit and feed on the crop plants. It is speculated that the repellent nature of the aluminum surface is associated with the insect's response to certain colors (13,15,23) and that the aluminum surface reflects radiation in certain portions of the color spectrum that is responsible for the repellent effect. In the present study, there was a close relationship between the level of TSWV incidence in crop plants and the relative numbers of thrips trapped on yellow sticky boards.

The use of an aluminum-surfaced film mulch is an effective method of reducing losses from the thrips-borne TSWV in certain crop plants. When this benefit is added to its previously recognized potential to reduce losses caused by aphid-borne viruses in crop plants, the use of reflective mulches appears to be an increasingly important strategy that can be employed against virus diseases.

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