HORTSCIENCE 28(9):895-896. 1993.

Delay in Mosaic Virus Onset and Aphid Vector Reduction in Summer Squash Grown on Reflective Mulches

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Additional index words. Cucurbita pepo, disease, plastic film, photoselectivity, silver mulch

Abstract. **Silver reflective plastic mulches were compared with conventional bare-ground culture of yellow crookneck summer squash *(Cucurbita pepo* L. var. *melopepo* Alef.) for reducing aphids and the following mosaic virus diseases: cucumber mosaic, watermelon mosaic I and II, zucchini yellows mosaic, and squash mosaic. Plants grown on silver plastic mulch produced higher marketable yields than those grown on bare ground. Other colors (white, yellow, and black with yellow edges) of plastic mulch were intermediate in their effects on aphid population and virus disease reduction. Silver reflective mulch alone and silver reflective mulch with insecticide were superior to other colors of plastic mulch in reducing aphid populations. Silver reflective plastic mulch, with or without insecticide, resulted in 10 to 13 days delay in the onset of the mosaic diseases noted.**

Yellow crookneck summer squash is an economically important crop grown widely in the southeastern United States. Production generally is limited to spring because several virus diseases are severe in late summer and fall (Chalfant et al., 1977).

Silver mulches have been used to reduce the incidence of virus disease in yellow summer squash and other crops (Chalfant et al., 1977; Conway et al., 1989; Lamont, et al., 1990; Lancaster et al., 1987; Moore et al., 1965; Simons, 1982; Smithetal., 1964; Wyman et al., 1979). Reflective mulches reduce the incidence of virus disease by confusing aphids, which vector the virus (Zalom and Cranshaw, 1981).

Insecticides have not controlled nonpersistent, insect-transmitted viruses effectively because viruses are transmitted before the vectors are killed (Broadbent, 1957; Chalfant et al., 1977). Systemic insecticides, however, can reduce secondary virus spread in the field by preventing the build up of vectors on primary virus sources (Chalfant et al., 1977).

The objectives of this study were to 1) determine the effect of silver mulch on virus disease control and 2) compare the effects of silver mulch with those of yellow, white, and black mulches on reducing alate aphid populations and on mosaic diseases.

In 1989, the test area was located at the Upper Coastal Plains Alabama Agricultural Experiment Station near Winfield on a fine sandy loam soil (clayey kaolinitic, thermic, Rhodic Kandiudult). Treatments were replicated four times in a randomized complete-block design and were as follows: 1) silver plastic (SP), 2) silver plastic with insecticide (SPI), 3) white plastic (WP), 4) yellow plastic (YP), 5) black plastic (BP), 6) black plastic with yellow edges (BPYE), 7) bare ground with insecticide (BGI), and 8) bare ground (BG). Each treatment consisted of three rows, 6.1 m long, spaced 1.5 m apart. Data were collected from the center row. Adjacent treatments in a replication were separated by a 1.5-m alley. Adjacent replications were separated by a 3.0-m alley. The soil was fertilized using 89 kg N and 44 kg P/ha; no K was needed. The 0.038-mm-thick, 1.5-m-wide plastic film (Edison Plastics Co., Washington, Ga.) was black on the upper and white on the under surface. The plastic was spray-painted to obtain the other colors needed by mixing equal parts of oil base paint and paint thinner. After the paint dried, 'Dixie' hybrid seeds were planted 46 cm apart within rows on 31 July.

Aphid populations were monitored by counting the number of aphids on the underside of three leaves in the center row of each plot on 7, 15, 22, and 29 Aug. and 5 and 12 Sept. Aphids were not identified by genus and species. All plots that received insecticide as part of their treatment were sprayed at 5- to 7-day intervals with 0,0-diethyl 0-[6-methyl-2-(1-methylethyl)-4-pyrimidinyl] phosphorothioate (diazinon) at 0.6 liters·ha^{-1}. Plots were harvested by hand on 28 Aug. and 2, 5, 8, 11,14, and 17 Sept. Marketable yields, by fruit weight, were determined.

In 1990, procedures were similar to those in 1989. In addition, a pan trap was placed in each treatment to measure alate aphid populations. Aluminum pans (20.3 cm long x 9.5 cm wide x 6.4 cm in diameter) were filled with a mixture of 1 ethylene glycol : 1 water, which was dyed yellow to match the pan color. A hardware cloth screen with 1.3-cm^2 openings was used to prevent wildlife from drinking the toxic solution. The number of aphids caught in each trap was recorded on 21 and 26 Aug. and 2, 8, 15, and 21 Sept. Border rows were planted on 6 July and inoculated artificially by hand with sap from virus-infected squash to ensure the presence of the viruses. Inoculum was prepared by grinding a 50-g leaf sample of infected plants from a commercial field in a mortar and pestle. During grinding, ≈ 10 ml 100 mM potassium phosphate (pH 7.0) was added and mixed with the tissue sample. Noninoculated plots were seeded 8 Aug. for the main squash planting. Cotyledons of squash plants in the guard rows were abraded using Carborundum powder sprayed from an atomizer. A few drops of the sap inoculum were rubbed on the cotyledons by applying light pressure. After the plants were inoculated, they were rinsed with water applied with a compressed-air sprayer. This inoculation method has been used successfully in the past (Robert T. Gudauskas, personal communication).

Soil moisture was monitored at 15 cm deep using two tensiometers. Irrigation was applied when the soil tension reading was 0.02 to 0.03 MPa. Methyl{ l-[(butylamino)carbonyl]-lH-benzimidazol-2-yl}carbamate (benomyl 50-WP) fungicide sprays were applied weekly at 0.56 kg a.i./ha. Plots were harvested at 3-day intervals from 9 Sept. to 8 Oct. Fruit were divided into categories of marketable and those exhibiting green mosaic symptoms.

Serological tests determined the following viruses: cucumber mosaic virus, cucumber mosaic virus (indigo strain), watermelon mosaic virus I (papaya ringspot virus), watermelon mosaic virus II, squash mosaic virus, and zucchini yellows mosaic virus. The enzyme-linked immunosorbent assay (ELISA) (AgDia Co., Elkhart, Ind.) was used. Data were tested with analysis of variance and treat-

Received for publication 4 Aug. 1992. Accepted for publication 10 May 1993. Alabama Agricultural Experiment Station Journal series no. 1 l-923302. The cost of publishing this paper was defrayed in part by the payment of page charges. Under postal regulations, this paper therefore must be hereby marked *advertisement* solely to indicate this fact.

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ments were compared with a least significant difference procedure (SAS Institute, 1988).

Marketable fruit yields in 1989 from mulched treatments, except for BP and WP, were significantly higher than those produced on BG (Table 1). Differences in marketable yield among the various colors of plastic mulch were not significant, except that yield was higher in plots with SP than those with BP. Aphid populations on squash leaves were reduced during the season on SP, with or without insecticide. No virus disease was detected in the plots. The highest mean aphid populations per three leaves occurred on 22 Aug. BGI and BG resulted in the highest populations, while BPYE, BP, WP, and YP produced intermediate numbers (Table 1). SP and SPI produced the lowest populations. Moore et al. (1965) also reported low aphid populations on plants grown with SP.

In 1990, SP and SPI resulted in the highest total marketable yield (Table 1). The only other significant treatment effect was that yields with WP were higher than those with BG. No differences were found among treatments for the yield of virus-infected fruit (Table 1). However, percentage of total fruit yield with mosaic symptoms was significantly less in SP and SPI plots than in the others, which ranged from 55% to 68%. These results agree with those of several other investigators (Black, 1980, Conway et al., 1989; Lamont et al., 1990; McLean et al., 1982). Aphid counts on squash leaves were too low and variable to detect differences in populations among treatments withrespect to aphid populations. However, the mean numbers of aphids caught in trap pans reflected statistical differences among treatments. The most aphids were caught in traps on 8 Sept. BGI and BG had the highest counts; WP, BP, and YP were intermediate; BPYE, SPI, and SP had the lowest counts (Table 1). These data concur with results reported by Wolfenbarger and Moore (1968).

In 500 individual serological samples, the following mosaic viruses were present with percentages as follows: cucumber mosaic virus, 52%; cucumber mosaic virus (indigo strain), 20%; watermelon mosaic virus I (papaya ringspot virus), 19%; watermelon mosaic virus II, 32%; zucchini yellows mosaic virus, 2.4%; and squash mosaic virus, 35%. Data were not collected in a manner to determine whether the serological test results were associated with treatments.

SP, with or without insecticide, delayed the onset of foliar mosaic virus symptoms ≈ 10 to 13 days when compared with BG, with or without insecticide (Fig. 1). Other colors of plastic mulch were intermediate in their effect on the incidence of virus diseases. These results are similar to results reported by Conway et al. (1989), Lamont et al. (1990), and Lancaster et al. (1987). This delay can mean significantly increased production in many commercial plantings. This effect, along with the other potentially beneficial aspects of plastic mulches, such as weed control and water conservation, suggests that silver reflective mulches could be a practical and economical management tool for producing summer squash. Regular embossed black mulch films cost about $750/ha, and the painted mulch ranged from $1000 to $1300/ha. According to Lamont et al. (1990) and considering our yields, the silver mulch is a cost-effective way to maintain marketable yield by reducing losses due to mosaic virus disease.

Table 1. Marketable fruit, virus-infected fruit, and mean number of aphids per leaf and per trap pan for summer squash grown with various plastic mulches.

	Marketable yield ($t\cdot ha^{-1}$)		Yield of fruit with symptoms (1990)		Mean no. of aphids per	
Treatment[z]	1989	1990	($t\cdot ha^{-1}$)	Mosaic (%)[y]	Leaf (1989)	Trap pan (1990)
SP	10.7 a[x]	10.8 a	7.2 a	40 e	6 cd	0.5 f
SPI	9.2 ab	10.3 a	6.6 a	39 e	2 d	1.3 ef
WP	8.5 a–c	7.0 bc	8.5 a	55 b–d	59 b	10.0 b
YP	9.4 ab	6.0 b–d	8.7 a	59 a–c	57 b	6.0 b–d
BP	8.4 b–d	4.9 cd	6.0 a	55 b–d	61 b	8.5 bc
BPYE	9.3 ab	4.9 cd	8.1 a	62 a–c	85 b	3.8 c–e
BGI	6.8 cd	3.9 cd	8.0 a	67 a	214 a	60.0 a
BG	6.2 d	3.4 d	7.2 a	68 a	212 a	45.0 a

[z]SP = silver plastic, SPI = silver plastic with insecticide, WP = white plastic, YP = yellow plastic, BP = black plastic, BPYE = black plastic with yellow edges, BGI = bare ground with insecticide, BG = bare ground.
[y]Percent mosaic = (yield of fruit with virus symptoms 1990)/(yield of fruit with virus symptoms 1990 + marketable yield 1990) × 100%.
[x]Mean separation within columns by LSD at $P \leq 0.05$.

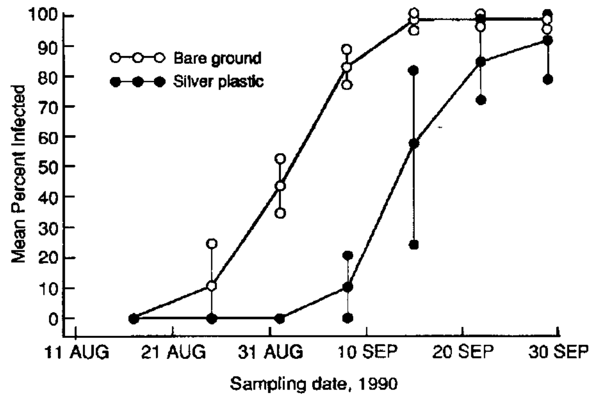

Fig. 1. Percentage of summer squash plants showing symptoms of virus diseases in 1990; 95% confidence intervals for the proportion of virus infection are given at each sampling date.

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