The Influence of Black Plastic Mulching on Infection Rates of Verticillium Wilt and Yield of Eggplant

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ABSTRACT

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Infection rates for Verticillium wilt in populations of four eggplant cultivars either grown on bare ground or mulched with black plastic ranged from 0.088 to 0.202 per unit per day in 1979, from 0.168 to 0.395 per unit per day in 1980, and from 0.150 to 0.276 per unit per day in 1981. Infection rates did not differ significantly among cultivars whether mulched or not mulched but differed significantly from year to year. Yields of mulched plants were greater than yields of plants not mulched. During one season, yields of eggplant grown in a *Verticillium*-infested field plot were 27–57% of yields of plants grown in an adjacent plot free of *Verticillium*.

Verticillium wilt, caused by *Verticillium dahliae* Kleb., can be a limiting factor in eggplant (*Solanum melangena* L.) production. The incidence of disease increases gradually in the plant population, typically causing yellowing and wilting of a few leaves and, in some cases, the entire plant. Because no eggplant cultivars are immune to Verticillium wilt, soil fumigation must be employed when the fungus population reaches a level that significantly suppresses yield. The objectives of this research were to compare the infection rate of Verticillium wilt in four eggplant cultivars and to determine whether black plastic mulching influences infection rates and yields of Verticillium-infected eggplant.

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MATERIALS AND METHODS

In 1979 and 1980, a field (Merrimac gravelly loam) was infested with *Verticillium dahliae* Kleb. microsclerotia as follows. After the field was prepared for planting, 500 ml of tap water containing approximately 255 microsclerotia per milliliter were shaken into trenches (10 cm deep, 25 cm wide, and 18 m long) in each of eight rows and then the trenches were filled. No microsclerotia were added in 1981. The fungus had been isolated originally in 1978 from an infected eggplant at the Suburban Experiment Station, Waltham, MA. Eggplant cultivars Satin Beauty, Beauty Hybrid, Black Beauty (from Ball Seed Co., P.O. Box 335, West Chicago, IL 60185), and Black Jack (from Agway, Inc., Seed Division, P.O. Box 4933, Syracuse, NY 13221) were seeded in 5.6-cm peat pots.

Eight weeks later, the plants were transplanted into mulched and nonmulched blocks, which were arranged in a checkerboard

pattern in the field. Six blocks were mulched with 0.04-mm (1.5-mil), 91.5-cm-wide black polyethylene plastic and six blocks were not mulched (bare ground). Each block had two side-by-side rows (1 m between row centers) and was two cultivars long (60 cm between plants) with five plants of each cultivar in a block. Thus, a total of 30 plants of each cultivar were mulched and 30 were grown on bare ground. A mulched block was approximately 7.2 m^2 in area. In 1980, a plot free of *Verticillium* adjacent to the infested plot was planted as above except only three blocks were mulched and three were not mulched. No plots free of *Verticillium* were established in 1979 or 1981. Fruits from all plants were harvested and weighed. Yield per plant was calculated.

Each week, all plants were examined for the early wilt disease symptoms of interveinal chlorosis on one or two leaves and slight wilting of leaf margins. In 1979, surface-disinfested petiole tissue from leaves exhibiting such symptoms was plated on water agar to confirm the presence of *V. dahliae* in the tissue. The date when symptoms were first observed was recorded for each plant. Neither the initial severity of the disease nor subsequent changes in severity were recorded. The $\log_e [x/(1-x)]$ transformation of the proportion of the population with disease (x) was plotted against the number of days after transplant. The slope (a) of the linear model fit to these data is the infection rate (11). The infection rates were determined for the entire population of 30 plants. Thus, each year one rate was determined for each cultivar mulched and each grown on bare ground. The criterion for evaluating the goodness of fit to the model was the coefficient of determination (r^2). Data were statistically analyzed according to a split-plot design (main plots were mulch and bare ground; subplots were cultivars; repetitions were years). Analysis of variance, F tests, Duncan's multiple range test, and linear regression analyses were applied where appropriate (9).

TABLE 1. Infection rates of Verticillium wilt in eggplant populations grown mulched with black polyethylene plastic film or on bare ground

		Mulched[x]		Not mulched[x]	
Cultivar	Year	Infection rate, a[y]	r^2[z]	Infection rate, a[y]	r^2[z]
Satin Beauty	1979	0.110	0.97	0.174	0.83
	1980	0.168	0.96	0.246	0.92
	1981	0.185	0.97	0.184	0.92
Black Jack	1979	0.120	0.96	0.115	0.97
	1980	0.270	0.96	0.315	0.94
	1981	0.150	0.99	0.226	0.97
Beauty Hybrid	1979	0.155	0.85	0.202	0.98
	1980	0.315	0.92	0.222	0.87
	1981	0.204	0.93	0.242	0.97
Black Beauty	1979	0.172	0.90	0.088	0.94
	1980	0.395	0.97	0.296	0.92
	1981	0.239	0.96	0.276	0.98

[x] Population = 30 plants of each cultivar mulched and 30 plants not mulched each year.
[y] Model $y = at + b$ in which a = slope of regression line and is the infection rate; t = logistic transformation ln $[x/(1-x)]$ of the proportion of the population disease (x); b = intercept.
[z] Coefficients of determination.

TABLE 2. Yield of eggplant grown with black plastic mulch or on bare ground in field plots infested with *Verticillium dahliae*

		Yield (kg/plant)			
Cultivar	Treatment[y]	1979	1980	1981	Mean[z]
Satin Beauty	M	2.5	2.2	1.6	2.3 a
Beauty Hybrid	M	2.4	1.4	2.6	2.1 a
Black Jack	M	2.5	1.4	1.7	1.9 ab
Satin Beauty	B	1.4	1.6	1.4	1.5 bc
Black Jack	B	1.0	1.3	1.2	1.2 cd
Black Beauty	M	1.3	0.8	0.9	1.0 d
Beauty Hybrid	B	0.7	1.1	1.0	0.9 d
Black Beauty	B	0.4	1.1	1.0	0.8 d

[y] M = mulched; B = bare ground.
[z] Means followed by the same letter are not significantly different ($P = 0.05$) according to Duncan's multiple range test (4).

TABLE 3. Yield of eggplant grown with black plastic mulch or on bare ground in field plot free of *Verticillium dahliae* in 1980

	Yield (kg/plant)	
Cultivar	Mulched	Bare ground
Satin Beauty	4.0	3.1
Black Jack	2.6	2.3
Beauty Hybrid	3.0	3.5
Black Beauty	3.0	2.0

RESULTS

Leaves with interveinal chlorosis and slight wilting of leaf margins first appeared 25–30 days after transplant. The presence of *V. dahliae* in those leaves was confirmed by the consistent isolation of the fungus from the petiole tissue. Half the plants exhibited symptoms 50–60 days after transplant and 100% of the population was often diseased by day 85. Infection rates ranged from 0.088 to 0.202 per unit per day in 1979, from 0.168 to 0.395 per unit per day in 1980, and from 0.150 to 0.276 per unit per day in 1981 (Table 1). Analysis of variance and subsequent F tests indicated that there were no significant differences among infection rates in the cultivars, nor between the rates in mulched populations and those grown on bare ground; however, the infection rates differed among years.

In 1980, yields of Verticillium wilt diseased plants were 27–57% of yields of plants free of the disease (Tables 2 and 3). Analysis of variance, F tests, and Duncan's multiple range test indicated that mulched plants, except for the cultivar Black Beauty, yielded more fruit weight per plant than plants not mulched when *V. dahliae* was present (Table 2).

The linear regression of apparent infection rates vs yield did not indicate a significant correlation between the two parameters.

DISCUSSION

Although Verticillium wilt did not normally kill plants, the population, regardless of cultivar, gradually became diseased until by season's end 90–100% of the plants exhibited symptoms. The infection rates of this disease differed from season to season, but in any given year, rates were similar in the cultivars, whether mulched or not mulched. Chester (1) also found that infection rates of Fusarium wilt of cotton in any given year were similar in the cultivars studied and that rates differed from year to year; however, the final incidence of disease at the end of the season differed among cultivars. Chester (1) concluded that, in the case of Fusarium wilt of cotton, seasonal weather governed the rate at which disease progressed, but that cultivar resistance and susceptibility governed incidence of disease in the population at the end of the season.

It is well recognized that environmental conditions strongly influence Verticillium wilt development. Talboys and Wilson (10) correlated high incidence of wilt in hops with low soil temperatures accompanying wet early season conditions. Guba (3) used black paper to mulch eggplant. He found that mulching elevated soil temperatures 5 cm deep to levels optimum for infection and that mulched plants, while growing more quickly than plants not mulched, developed wilt disease symptoms 7–10 days earlier and more severely than plants grown on bare ground. Although plant growth early in the season was promoted by mulching in the present study, wilt did not appear sooner in mulched than in plants on bare ground. Black plastic mulching did not significantly alter the infection rate as compared to plants not mulched.

Disease severity did not appear to be greater in mulched plants than in those grown on bare ground. The lack of correlation

between rates of disease increase and yields was not unexpected. Only the date of the first symptom expression was recorded; neither the initial disease severity nor the subsequent change in severity was recorded. It was frequently observed that some plants exhibited symptoms early in the season but symptom severity increased slowly or not at all. Yield is probably more closely correlated with the rate of increase in disease severity in the plant population than with the infection rate as measured by the first appearance of symptoms.

The appropriateness of employing the "compound interest disease" (CID) model (11) to the data can be questioned. In CID, or polycyclic diseases, the pathogen in a diseased plant can be the source of inoculum for additional plants during the same season. The CID model was used here to describe the data because of the consistently higher coefficients of determination (r^2) obtained as compared to the "simple interest disease" (SID) model (11). Pfender (7) warns that SID and CID models are based on the biology of disease progress and that biological processes cannot be properly deduced from the observed data by referring to either model. Verticillium wilt is a soilborne disease in which the initial inoculum is the microsclerotium population in crop debris and soil in the field (2). There are no published reports of plant to plant spread of *V. dahliae* in eggplant. Isaac (4), McKay (5), and Roberts (8) presented strong evidence from greenhouse and field experiments that *Verticillium* spreads among plants in tomato and potato crops. It has been observed by the author that Verticillium-diseased plants tend to be clustered (*unpublished*). Further work must be completed to determine whether such clustering is merely due to areas of high microsclerotium populations in the field or a result of plant to plant spread. If plant-to-plant spread is proven, the appropriateness of applying the CID model to Verticillium wilt of eggplant will be confirmed.

Verticillium wilt can greatly suppress eggplant yields (Tables 2 and 3). Mulching ameliorated yield loss due to disease in three of the four cultivars grown. Similar trends have been observed in other cultivars (6). Mulching to avoid some yield reduction would be useful in fields where populations of *Verticillium* are not excessive and where soil fumigation is not performed every season. Finally, it should be recognized that although no cultivars are immune to Verticillium wilt, they do differ in yield reduction when diseased. If soil fumigation is not feasible, cultivar selection could be the determining factor in the success or failure of eggplant production when *V. dahliae* is present.

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