Reduction of Bacterial Wilt by Early Harvest of Tomato Transplants

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ABSTRACT

Tomato plants grown in fields of southern Georgia infested with *Pseudomonas solanacearum* and transplanted at Beltsville, Md., showed a higher incidence of bacterial wilt when harvested and transplanted late in the season than when harvested early. In 1970, wilt in hand-pulled plants ranged from 3.3 and 1.3% in plants harvested on 14 and 27 May to 35.6% in plants harvested on 10 June. Plants removed from the soil with a shovel to simulate machine harvest usually did not show more wilt than hand-pulled plants. A higher incidence of wilt in late- than in early-harvested plants with a uniform root-dip inoculation indicated that factors in addition to holding period of transplants in southern fields are involved. Phytopathology 61:849-851.

Additional key words: vascular pathogen, *Lycopersicon esculentum.*

Southern bacterial wilt caused by *Pseudomonas solanacearum* is one of the most destructive diseases of tomato transplants grown in southern Georgia for shipment to northern fruit-producing areas. In some transplant fields, *P. solanacearum* causes high mortality, but a greater loss occurs because fields of less severely diseased plants are rejected by the Georgia Department of Agriculture to prevent spread of the bacterium. Despite these regulatory procedures, several reports indicate that some spread does occur (4, 5, 6, 9). Observations made over several years indicated a lower incidence of bacterial wilt in northern areas in plants harvested early in the season than in those harvested later, even though the latter might not show symptoms at harvest. We hypothesized that plants grown even in heavily infested soil might not succumb in northern areas if transplant harvest were made early in the season. We conducted the present study to determine any relationship between harvesting and transplanting dates and the incidence of bacterial wilt among southern-grown plants when transplanted in northern areas. Machine harvest of transplants is currently being investigated (1). We also simulated machine harvest to determine any influence of this practice on the incidence of bacterial wilt among transplants.

MATERIALS AND METHODS.—Tomato (*Lycopersicon esculentum* Mill.) plants for shipment were grown near Tifton, Ga., each spring from 1968 to 1970 (Table 1). Plant beds were 2 m wide with four rows on 0.35-m centers. Seeding rate was 120 seed/m of row. Plants were grown according to recommended practices (2), and size was regulated by scheduled clipping with a rotary mower (3). Each year, beds of plants were established in fields infested with *Pseudomonas solanacearum* and where the organism had not been found (check). Selection of the infested and pathogen-free sites was based on wilt incidence among tomato crops grown in the fields in previous years. During each spring, plants were harvested on three dates to represent early-, middle-, and late-season harvests as practiced by the grower, except in 1968, when the late harvest was eliminated because of a high incidence of stem canker caused by *Alternaria solani* (Table 1). Treatments used at each harvest were as follows: (i) plants pulled by hand from infested soil; (ii) plants lifted from infested soil with a shovel to simulate machine harvest (greater volume of roots removed than in hand-pulled plants); (iii) plants pulled by hand from noninfested soil, and roots dipped for 30 sec in a *P. solanacearum* suspension; and (iv) plants pulled by hand from noninfested soil (check). The root-dip treatment was used to determine incidence of wilt in northern areas after uniform inoculation of plants prior to shipment. The inoculum for the root dip was prepared by suspending growth from petri dish cultures (grown at 35 C for 4 days on potato-dextrose agar) in distilled water, except in the midseason harvest of 1970, when the suspension was prepared from diseased tomato plants. The suspensions were adjusted to contain 10^7 cells/ml. Plants for the four treatments were pulled at random from 75 or more feet of bed length. Any plants showing symptoms of bacterial wilt or other diseases were avoided.

Plants were wrapped in paper in bundles of 50 with their roots surrounded by moist peat moss, packed in keystone shaped crates according to commercial practice (8), and shipped via air express to Beltsville, Md.; they were transplanted as soon as possible after arrival. Plants from each harvest were arranged in a randomized complete block design of four replications with 68 to 75 plants/replicate in 1968, and 100 plants in 1969 and 1970. All plants were grown according to recommended practices for the area. Initial survival counts were taken soon after transplanting so that losses due to transplanting shock and unfavorable weather conditions could be eliminated from total loss figures. Final wilt data were based on the number of plants surviving transplanting. Plots were observed for

TABLE 1. Cultivars and dates of various cultural practices used on tomatoes grown in bacterial wilt experiments from 1968 to 1970

Year	Tomato cultivar	Seeding date	Clipping dates	Early season		Midseason		Late Season	
				Harvested	Transplanted	Harvested	Transplanted	Harvested	Transplanted
1968	C-17	21 March	9, 17 May	9 May	13 May	22 May	24 May	[a]	[a]
1969	H-1439	23 March	11 May	11 May	13 May	19 May	22 May	28 May	29 May
1970	Mars	8 April	8, 16, 27 May	14 May	18 May	27 May	1 June	10 June	12 June

[a] No late-season harvest was made in 1968 due to severity of *Alternaria solani*.

wilted plants at 7- to 10-day intervals from May to August. To test for bacterial wilt, plants showing wilt symptoms were cut near the soil level, and a section of the stem was suspended in water to check for streaming of the wilt bacterium from the vascular system (5).

RESULTS.—Generally, incidence of bacterial wilt in southern-grown plants transplanted at Beltsville, Md., increased as the transplant harvest and subsequent transplanting dates were delayed (Table 2). The greatest increase occurred between the mid- and late-season harvests in 1969 and 1970, although there was a significant difference in wilt incidence between the early- and midseason harvests in 1968. Except for a higher incidence for the hand harvest in 1969, the wilt incidence between plants harvested by simulated machine and plants harvested by conventional hand pulling did not differ significantly. The 3-year means for the two treatments were similar (10.3 compared with 9.7%). Plants grown in noninfested soil and dipped in a bacterial suspension succumbed to wilt ranging from 8.4% (early harvest, 1969) to 55.3% (late harvest, 1970). Losses in this treatment were generally greater in late-harvested plants than in plants harvested and transplanted early. There was a low incidence of bacterial wilt in plants grown in soil that was assumed to be free of the pathogen. The highest wilt incidence in plants from this soil was 12.6%, and occurred in the later harvest of 1970.

Plants with bacterial wilt were observed in the beds of infested soil in southern Georgia. In 1969, some plants were showing initial symptoms as early as 9 May. Although the dates for the onset of first symptoms were not recorded in 1968 and 1970, some plants were wilting by the time the last shipments were made.

DISCUSSION.—Our results show that the incidence of bacterial wilt in northern fields increases as clipped transplants are held in southern production fields having natural infestations of *P. solanacearum*. Delaying transplant harvest greatly increases the possibility of having significant losses due to bacterial wilt in southern transplant fields and in northern fields receiving the transplants. The higher incidence of bacterial wilt in the late-harvested plants in 1970 than in 1969 was probably due to the longer holding period prior to harvest and shipment. The designations early-, mid-, and late-season were relative for each year, and the late

TABLE 2. Incidence of bacterial wilt in tomato plants associated with different treatments and transplant harvest dates[a]

Treatment	Southern plant harvest date	% Wilted plants at Beltsville, Md.[b]							
		1968		1969		1970		3-Year mean	
		Treatment × harvest	Treatment mean	Treatment × harvest	Treatment mean	Treatment × harvest	Treatment mean	Treatment × harvest	Treatment
Infested soil, hand harvest	Early	0.7[v]	8.2[v]	0.5[v]	9.2[w]	3.3[v]	13.4[w]	1.5	10.3
	Midseason	15.7[w]		3.3[v]		1.3[v]		6.8	
	Late[c]			23.8[w]		35.6[xy]		29.7	
Infested soil, simulated machine harvest	Early	0.7[v]	9.0[v]	2.8[v]	3.8[v]	1.9[v]	16.2[w]	1.8	9.7
	Midseason	17.3[w]		2.3[v]		2.8[v]		7.5	
	Late			6.4[v]		43.8[y]		25.1	
Noninfested soil, hand harvest, root dip	Early	8.7[vw]	19.9[w]	8.4[v]	13.9[x]	14.5[w]	32.9[x]	10.5	22.2
	Midseason	31.2[x]		9.1[v]		28.9[x]		23.1	
	Late			24.2[w]		55.3[z]		39.8	
Noninfested soil, hand harvest (Check)	Early	0.3[v]	0.5[v]	0.3[v]	1.3[v]	2.7[v]	5.7[v]	1.1	2.5
	Midseason	0.7[v]		0.6[v]		1.8[v]		1.0	
	Late			3.0[v]		12.6[vw]		7.8	
Harvest mean	Early	2.6[v]		3.0[v]		5.6[v]		3.7	
	Midseason	16.2[w]		3.8[v]		8.7[v]		9.6	
	Late			14.4[w]		36.8[w]		25.0	

[a] Plants were grown near Tifton, Georgia and were transplanted at Beltsville, Maryland.

[b] Column means having the same letter are not significantly different ($P = .05$) according to Duncan's multiple range test.

[c] No late-season harvest was made in 1968 due to severity of *Alternaria solani*.

harvest for 1970 was 13 days later than the same harvest in 1969. The higher disease incidence in late- than in early-harvested plants with their roots dipped suggests that factors in addition to the holding period in southern fields are involved. The most likely cause was the more favorable environmental conditions for disease development at Beltsville with later planting. Differences in movement of the bacteria into the plants or host susceptibility with different harvest dates may also be involved. The root-dip treatment proved to be a very effective means of inoculating transplants with the wilt bacterium. There is considerable interest in the use of bare-root shipment of transplants to reduce packaging costs. It has been suggested that roots of these plants might be placed in water to prevent drying, should they be held for extended periods in northern areas due to adverse weather conditions. Our results indicate the inadvisability of such a practice, since a few infected plants could exude sufficient bacteria into the water to inoculate a high percentage of healthy plants.

Machine harvesting of transplants removes more roots than hand pulling. It has been postulated that shipment of a larger root system might increase the possibility of disseminating soil-borne plant pathogens. Our results do not indicate that machine harvesting will increase the incidence of bacterial wilt.

Clipping was used to regulate plant size so that plants could be held in the field. Earlier work (7) showed that the wilt organism could be spread from diseased to healthy plants by clipping with a rotary mower. Similar clipping was done in the present test, but we do not know if significant spread occurred. The low incidence of wilt in the so-called pathogen-free soil was probably due to a low infestation of *P. solanacearum* that had not been detected in previous years. This low infestation was most evident in late-harvested plants.

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