

was not unusual, although not statistically analyzed, and could not be associated with cultivar, media, or fertilizer. Frequency of abnormal fruit increased slightly during the seventh and eighth harvests because of the declining condition of the plants. Tomatoes were harvested during the last half of the greenhouse production season during late March, April and May. This was a period of increasing temperatures with highs over 95°F not uncommon.

Due to the small differences in composition as a result of the various treatments, the selection of fertilizer or media to be used could be on the basis of economics and availability. No particular treatment was outstanding enough to warrant recommendation.

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## EFFECT OF TEMPERATURE AND SHORT DAY ON DEVELOPMENT OF VERTICILLIUM WILT OF SUSCEPTIBLE, TOLERANT, AND RESISTANT TOMATO CULTIVARS<sup>1</sup>

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**Abstract.** Elevated temps and short day conditions favored development of Verticillium wilt of susceptible, tolerant, and resistant tomato cultivars. The percentage of wilted plants and symptom severity of root-dip inoculated 'Tropic' (a cultivar that possesses the Ve gene for resistance) seedlings increased as the incubation temp increased from 20 to 32 C. Additionally the percentage of inoculated 'Tropic' plants from which *V. albo-atrum* race 1 was isolated increased with increasing incubation temperature. At 20 C the pathogen was isolated from 40% of the inoculated plants but only 10% of the plants exhibited symptoms. Resistance conferred by the Ve gene in 'Tropic' appeared to be reduced under conditions favoring maximum development of Verticillium wilt.

For the past few years we have been involved in developing techniques for evaluating tomato (*Lycopersicon esculentum*) cultivars and breeding lines for resistance to Verticillium wilt incited by *Verticillium albo-atrum* Reinke and Berth race 1. The occurrence of Verticillium wilt was discovered to dramatically increase as the daily light duration was decreased from 16 to 4 hours. A 4 hour daily photoperiod was then incorporated into our experiments on the interaction of *V. albo-atrum* and nematodes and for the routine evaluation of breeding lines. In a nematode-Verticillium interaction experiment, wilt development was much greater at 27 C than at 21 C and in a breeding line

evaluation experiment, seedlings of the 'Tropic' cultivar developed wilt symptoms when root-dip inoculated and incubated in growth rooms of 4 hour light duration and 27 C. 'Tropic' contains the Ve gene for resistance to race 1 (4), and with one exception (1), indicates that the Ve gene results in less than perfect control of *V. albo-atrum* race 1. These observations prompted us to design and carry out 2 experiments to determine the effect of increasing temperature (coupled with a 4 hour daily photoperiod) on the development of Verticillium wilt of tomato. The results of these 2 experiments and the 2 preliminary *Verticillium-nematode* and cultivar evaluation experiments are presented herein.

#### Materials and Methods

**General Methods:** Two-week-old seedlings of diverse cultivars were root-dip inoculated (6) with *V. albo-atrum* race 1, transplanted into a sterile commercial peat:vermiculite mix contained in styrofoam trays, and incubated in temperature controlled growth rooms. A 4 hour daily photoperiod was used in all experiments and was provided by cool-white fluorescent tubes. A light intensity of 7,535 lux was used in experiments 1 and 2 and of 6,458 lux in experiments 3 and 4. Noninoculated plants of each cultivar were used as controls in each experiment.

The *V. albo-atrum* race 1 used for inoculum in all experiments was cultured 2 weeks at 21 C under 81 lux continuous illumination on potato-dextrose agar in petri dishes. The cultures were comminuted in sterile, deionized water and the resulting dense mycelial-conidial suspensions were used as inocula.

All plants were examined weekly or twice weekly for external symptoms of Verticillium wilt. No reisolation of the pathogen was attempted except in experiment 4.

**Experiment 1:** This experiment was designed to delve into the interaction of *V. albo-atrum* and various phyto-

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parasitic nematodes. Seedlings of the cultivars 'Walter' and 'Manapal' were inoculated ( $11.5 \times 10^7$  spores/ml) and incubated at either 21 or 27 C. Each experimental unit consisted of 12 plants and was replicated 12 times. Disease evaluations were made 1 and 2 weeks after inoculation.

**Experiment 2:** This experiment was designed to determine the disease reaction of the cultivar 'Floramerica' to Verticillium wilt. Seedlings of the cultivars 'Bonny Best' (susceptible), 'Walter' (field tolerant), 'Floramerica' (disease reaction unknown), and 'Tropic' (resistant) were inoculated ( $5.6 \times 10^7$  spores/ml), incubated at 27 C, and evaluated for wilt symptoms 12 and 15 days later. Each experimental unit consisted of 50 plants and was replicated 4 times.

**Experiment 3:** Seedlings of 'Bonny Best,' 'Walter,' and 'Tropic' were inoculated with each of four different isolates of *V. albo-atrum* (all race 1) and incubated at 20, 24, 28, and 32 C. One isolate was obtained from California, and the 3 remaining isolates were obtained from different Florida locations. Data from the 4 isolates were pooled. Inocula concn varied from  $2.5 \times 10^7$  to  $5.1 \times 10^7$  spores/ml, depending on the isolate used. Each experimental unit consisted of 20 plants and was replicated 12 times. All plants were evaluated for wilt symptoms 22 days after inoculation.

**Experiment 4:** Seedlings of the cultivar 'Tropic' were inoculated with each of 2 Florida isolates ( $3.7$  and  $3.3 \times 10^7$  spores/ml) and incubated at 20, 24, 28 and 32 C. All plants, inoculated or noninoculated, in the previous experiment died following incubation at 32 C for 1 week. Therefore, the set of plants destined for 32 C was incubated 1 week at 28 C then placed at 32 C. After 3 weeks incubation all surviving plants were uprooted and hypocotyl sections were excised, surface sterilized, and plated on potato-dextrose agar. Results from the 2 isolates were pooled.

## Results and Discussion

**Expts 1 and 2:** Although expt 1 was established to determine the effect of phytoparasitic nematodes on development of Verticillium wilt, it soon became obvious that wilt development was far greater at 27 than 21 C (Table 1).

Table 1. Percentage diseased and dead plants after inoculation with *V. albo-atrum* and incubation at 21 or 27 C and under a 4 hr daily photoperiod.

Cultivar	Percent plants diseased after				Percent plants dead after	
	1 wk incubation at		2 wk incubation at		2 wk incubation at	
	21 C	27 C	21 C	27 C	21 C	27 C
Manapal	8	43	66	98	8	29
Walter	11	42	55	96	10	17
Mean	9.7	42.7	60.7	97.0	9.0	23.0

Table 3. Effect of incubation temp and a 4 hr daily photoperiod on development of Verticillium wilt on 3 tomato cultivars 11 and 22 days after inoculation.

Incubation temp (°C)	11 day incubation			22 day incubation					
	BB*	Walt	Trop	BB		Walt		Trop	
	Dis.†	Dis.	Dis.	Dis.	Dead‡	Dis.	Dead	Dis.	Dead
	%	%	%	%	%	%	%	%	%
20	8	26	5	99	40	99	32	36	3
24	32	64	7	99	80	97	65	40	3
28	50	68	40	98	55	99	64	68	13

\*BB = Bonny Best, Walt = Walter, Trop = Tropic.

†Percentage inoculated plants exhibiting wilt symptoms.

‡Percentage inoculated plants dead.

In expt 2, designed to evaluate 'Floramerica' for resistance to Verticillium wilt, 'Tropic' seedlings developed wilt symptoms (Table 2) despite the fact that the cultivar contains the Ve gene for resistance to race 1.

Essentially all noninoculated plants in expts 1 and 2 remained disease free.

**Expt 3:** The results of expts 1 and 2 prompted the initiation of expt 3 to determine the effect of incubation temp, in conjunction with a 4 hour daily photoperiod, on development of Verticillium wilt of susceptible ('Bonny Best'), tolerant ('Walter'), and resistant ('Tropic') cultivars.

After 11 days incubation the incidence of wilt of 'Bonny Best' increased with increasing temp, whereas with 'Walter' disease incidence peaked at 24 C (Table 3). Few 'Tropic' seedlings after 11 days incubation at 20 and 24 C exhibited wilt symptoms. However, 40% of the plants incubated at 28 C developed symptoms after 11 days incubation.

After 22 days incubation nearly all of the 'Bonny Best' and 'Walter' seedlings were diseased regardless of incubation temp (Table 3). The percentage of 'Tropic' seedlings with wilt symptoms increased with increasing incubation temp until at 28 C nearly 70% were diseased.

All plants (regardless of cultivar and whether inoculated or not) incubated at 32 C died within one week.

Only 2 noninoculated plants incubated at 20, 24, or 28 C developed wilt symptoms.

**Expt 4:** This expt was designed to determine the effect of incubation temperature (with a 4 hour daily photoperiod) on development of Verticillium wilt on a Ve gene cultivar ('Tropic') following inoculation with *V. albo-atrum* race 1.

After 3 weeks incubation the incidence and severity of wilt of 'Tropic' increased with increasing incubation temp (Table 4). Also the number of plants from which *V. albo-atrum* was isolated increased as incubation temp increased (Table 4).

At 20 C only 10% of the inoculated 'Tropic' seedlings exhibited wilt symptoms although the pathogen was isolated from 40% of the plants. As the incubation temp increased the disparity between plants with symptoms and plants with

Table 2. Percentage diseased and dead plants of 4 cultivars after inoculation with *V. albo-atrum* and incubation 12 and 15 days at 27 C under a 4 hr daily photoperiod.

Cultivar	Days after inoculation			
	12		15	
	% plants diseased	% plants dead	% plants diseased	% plants dead
Floramerica	84	25	90	45
Bonny Best	96	50	98	88
Walter	97	37	100	74
Tropic	15	1	23	6

Table 4. Effect of a 4 hr photoperiod and various incubation temperatures on development of Verticillium wilt symptoms on the Ve gene cultivar 'Tropic' and on the reisolation of *V. albo-atrum*.

Incubation temp (°C)	Percent inoculated plants		
	Developing wilt symptoms	Moderately diseased to dead	Yielding Verticillium colonies
20	10	0	40
24	32	2	68
28	61	11	78
32	88	38	92

the pathogen decreased, so that at 32 C, 88% of the inoculated plants were wilted and *V. albo-atrum* was isolated from 92% of the inoculated plants. Apparently at the cooler temp (i.e. 20 C) the pathogen invaded the hypocotyl of resistant seedlings but was unable to incite disease. This phenomenon is similar to Fusarium wilt of tomato where nonpathogen races are routinely isolated from symptomless plants of resistant cultivars (3).

Wilt-like symptoms developed on 10, 8, 15, and 13% of the noninoculated seedlings incubated at 20, 24, 28, and 32 C, respectively. However, *V. albo-atrum* was isolated only from 2.5, 5.0, 7.5, and 0% of the noninoculated seedlings incubated at 20, 24, 28, and 32 C, respectively.

*General:* It is apparent that elevated temp, coupled with short day conditions, favored development of susceptible and tolerant cultivars.

Resistance to Verticillium wilt conferred by the Ve gene in 'Tropic' also was greatly reduced by the severe environmental conditions of these experiments. Perhaps this should not be surprising since high soil temp have been shown to reduce monogenic resistance to several diseases (5). None-

theless, the reduction of resistance conferred by the Ve gene by high temp was not anticipated because Verticillium wilt has been considered a cool weather disease and with the exception of one paper (1) no report was found indicating that the Ve gene ever failed to control Verticillium wilt incited by *V. albo-atrum* race 1.

In Florida, and perhaps elsewhere, the environmental range for expression of Verticillium wilt on tomato seedlings seems to be so narrow that many escapes occur and susceptibility expression is suppressed. Consequently, it is very important to provide uniform evaluating conditions from season to season. Root-dip inoculating tomato seedlings with *V. albo-atrum* race 1 and incubating these seedlings 2 weeks at 27 C with a 4 hour daily photoperiod gives screening results (Table 2) that correlate very well to results obtained by screening mature plants under field conditions. The very precise method results in the detection of polygenic tolerance, monogenic resistance, and susceptibility, especially if carried out with standard resistant, tolerant, and susceptible tester lines.

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## PICKLEWORM CONTROL ON CANTALOUPE AND SUMMER SQUASH

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*Additional index words.* *Cucumis melo* L., *Cucurbita pepo* L., *Diaphania nitidalis*.

**Abstract.** In 3 insecticide tests for the control of pickleworm, *Diaphania nitidalis* (Stall), Lannate, Nudrin, Bolstar, Sevin, and Dylox gave consistently good control. In tests that were not repeated, good results were obtained with Thiodan, Phosvel, and the synthetic pyrethroid Pydrin. Results with Furadan, Orthene, and Imidan were inconsistent and with Fundal and Sumithion were inconclusive. 'Burpee Hybrid Zucchini' squash was more susceptible to pickleworm damage, and thus harder to protect than 'Early Golden Summer Crookneck'. On zucchini best results were with Lannate, Nudrin, and Bolstar. Worm free yield of 3 untreated honeydew-type melons exceeded 90%.

Pickleworm, *Diaphania nitidalis* (Stall) overwinters in south Florida (4) and moves northward each year usually

arriving in central Florida in March or early April. Squash, cucumber, and cantaloupe may be seriously affected, especially when planted in the fall. Flower and leaf buds are eaten, and fruits and vines are tunneled. Yields may be markedly reduced unless the crop is protected by insecticides. Alternative control methods are not available, and parasites and predators are apparently of no significant benefit (3). Chemical control experiments on cantaloupe and summer squash are described herein.

#### Materials and Methods

In the spring and fall of 1975, and in the fall of 1976 chemical control experiments were conducted on cantaloupe and honeydew type melons, cucumbers, and summer squash. All were planted in hills spaced 2.5 ft apart in rows 10 ft apart. All plots had paired rows of 2 cultivars, 9 hills per row. The pairs were 'Gulfcoast' cantaloupe-'Morgan' melon, 'Edisto' cantaloupe-'Poinsett' cucumber, and 'Early Golden Summer Crookneck'-'Burpee Hybrid Zucchini' squash. All experiments were in randomized blocks. The 'Morgan' melon sustained little damage and 'Poinsett' cucumber data were incomplete, so only cantaloupe and squash insecticide records are presented.

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