Integration of Host Resistance and Weather-Based Fungicide Scheduling for Control of Anthracnose of Tomato Fruit

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ABSTRACT

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The relationship between anthracnose resistance of tomato cultivars and disease incidence at various fungicide application intervals (determined by a weather-based scheduling program) was evaluated in field studies in 1992 and 1993. The resistance of tomato cultivars was indexed relative to the disease response of a standard susceptible cultivar in evaluations conducted in a disease nursery. Five different fungicide application intervals, based on action threshold values determined by the TOM-CAST program (12, 16, 20, 24, or 32 daily severity values), were tested on five tomato cultivars that represented a range of resistance currently available in commercial production. The relationship between application interval and disease incidence was determined by linear regression techniques for each cultivar. The slope of the regression for each cultivar was designated as a TOM-CAST anthracnose coefficient (TAC). TAC values were regressed on resistance indices to estimate optimum fungicide spray intervals for cultivars with different degrees of resistance. Results indicated that, with the TOM-CAST program, resistant cultivars require three to four fewer fungicide applications per year than susceptible cultivars to obtain adequate control of anthracnose. Optimum action threshold values may be increased from current recommendations by at least two-fold for resistant cultivars currently under development.

Tomato anthracnose, caused by *Colletotrichum coccodes* (Wallr.) Hughes, is a major disease of tomatoes grown for processing in the northeastern and north central regions of North America (11). The disease causes sunken, circular lesions on ripe fruit. Other plant parts can be infected by the fungus but the role of these infections in the epidemiology of the disease is not well characterized (15). Incidence of fruit infection can approach 15% in commercial fields (19) and may result in reduced crop value because of poor fruit quality (12).

Although sources of resistance have been identified (1,2,5), levels of resistance in commercial cultivars are not sufficient to control the disease without fungicide sprays. Growers rely on repeated applications of protectant fungicides (as many as 12 sprays per season) to avoid losses caused by anthracnose.

Concerns about pesticide costs and residues in processed foods have prompted researchers to investigate application alternatives that reduce fungicide use without increasing risk of disease-related losses. FAST (Forecaster of *Alternaria solani* on Tomato) is a disease-warning system that determines when environmental conditions (temperature, relative humidity, and rainfall) are favorable for development of tomato early blight and advises on the timing of fungicide applications (13). The FAST system improves the efficiency of fungicide applications for controlling tomato early blight (17). TOM-CAST, an adaptation of the FAST program, has been used successfully on tomatoes in Ontario for protection against anthracnose, early blight, and Septoria leaf spot (18). With TOM-CAST, air temperature and leaf wetness are used to generate daily severity values (DSV) that accumulate over time. Fungicide sprays are recommended when accumulated severity values reach a predetermined threshold.

Host resistance also may be used to reduce the amount of fungicide used to provide acceptable levels of disease control. Fry (7) quantified the relationship between host resistance of potato cultivars and the amount of fungicide required to control potato late blight caused by *Phytophthora infestans*. It was shown that as plant resistance increased, less fungicide was necessary to achieve adequate disease control when fungicides were applied at regular intervals or according to a weather-based forecasting system (8). The effectiveness of host resistance in improving fungicide use efficiency has been demonstrated for other crops (14,16).

Previous research on tomatoes (2,3) demonstrated that host resistance can be used to achieve acceptable levels of control with fewer fungicide applications. This research was designed to investigate the integration of host resistance and the TOM-CAST forecaster for control of tomato anthracnose. Specific objectives included quantifying resistance levels of tomato cultivars and determining whether fungicide application intervals can be lengthened for resistant cultivars.

MATERIALS AND METHODS

Inoculum preparation. An isolate of *C. coccodes* obtained locally from naturally infected tomato fruit was used to prepare inoculum for all field studies. The isolate was preserved on silica gel granules and stored at 4 C. Cultures were recovered by adding several silica gel granules to acidified potato-dextrose agar in petri dishes. The cultures were incubated 2–3 wk under a 12-hr diurnal lighting regime at 24±2 C.

Inoculum for field experiments was increased on autoclaved white millet seed (200 cc millet seed and 20 ml of distilled water per 1L Erlenmeyer flask). The sterilized millet was inoculated with pieces of the agar medium containing mycelium from the 2- to 3-wk-old *C. coccodes* cultures. The flasks were placed in continuous fluorescent light at 24 C and shaken every 3–4 days to redistribute the mycelium. Three weeks after inoculation, the colonized millet seed was poured into paper bags that were then left open for 3 days in a greenhouse to dry the seed (temperature ranged from 21 to 32 C). The dried colonized millet seed was then stored in a dry location until it was used.

Transplant preparation. Seeds of tomato cultivars to be evaluated were planted in 128-cell plastic growing trays. The trays contained a commercially prepared soilless potting mix (Terra Lite Vegetable Plug Mix, W. R. Grace & Co., Cambridge, MA). The trays were thinned to one plant per cell 2 wk after emergence. Starter fertilizer (1.3 g/L, 10-52-8 NPK, Warsaw Chemical Co., Warsaw,

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IN) was added to the plants 1 wk before transplanting. Prior to transplanting, the seedlings were environmentally conditioned by placing them outside during the day (approximately 8 hr each day) for 1 wk.

Resistance evaluations. The resistance of tomato cultivars and breeding lines (hereafter collectively referred to as cultivars) was evaluated in an anthracnose nursery from 1991 to 1993 at the Purdue O'Neall Horticultural Research Center in Lafayette, IN. The experimental design was a randomized complete block with four replications. Each plot consisted of a single row of five plants spaced 46 cm apart. Rows were spaced 183 cm apart in 1991 and 1992 and 152 cm apart in 1993. Plots were inoculated with millet seed infested with *C. coccodes* when the first fruit clusters began to develop on the plants. Approximately 50 g of millet seed was manually spread on the soil surface under the plants in each row.

Individual plots were harvested when at least 70% of the fruit in the plot were ripe. One hundred fruit, arbitrarily selected from two plants in the middle of each plot, were evaluated for the presence of anthracnose lesions. The percentage of fruit with anthracnose lesions from each plot was recorded. A resistance index (RI) was calculated for each cultivar by dividing its mean percentage of fruit with anthracnose lesions by the mean percentage of fruit with anthracnose lesions observed on the standard susceptible cultivar Ohio 7814.

Host resistance/fungicide application interval experiments. Three field experiments involving selected tomato cultivars and various fungicide application schedules were conducted at the Purdue O'Neall Horticultural Research Center in 1992 and 1993 (experiment I in 1992, experiments II and III in 1993) (Table 1). The plants were transplanted on 14 May in 1992 and 27 May in 1993. Trifluralin (0.84 kg a.i./ha) was incorporated 24 hr before transplanting. Fertilizer (19-19-19) was applied at a rate equivalent to 532 kg/ha in 1992 and 1993. The experimental design was a split plot with four replications. Whole plots were treated with chlorothalonil (Bravo 720, ISK Biotech, Mentor, OH) at a rate equivalent to 1.65 kg a.i./ha according to calendar-based application schedules or the TOM-CAST program using 12, 16, 20, 24, and 32 DSV action thresholds.

Each whole plot consisted of two rows of three subplots each for a total of six subplots. Five of the subplots contained one of five tomato cultivars (Ohio 8245, Ohio 7814, Ohio 8550, Hypeel 696, and SO-12). The sixth subplot was planted with a commercial cultivar to avoid possible variation due to different row lengths but was not included in any statistical analysis. The arrangement of the cultivars within the 2-row plots was randomized across replications. Plants were spaced 46 cm apart. Each treatment row was bordered on one side by an untreated spreader row containing a susceptible cultivar (Murrieta in 1992 and Ohio 8550 in 1993). Rows were spaced 183 cm apart in experiments I and II. Due to space constraints the rows were spaced 152 cm apart in experiment III.

Approximately 200 cc of millet seed infested with *C. coccodes* was manually distributed under the plants in each spreader row. All spreader rows were inoculated approximately 7 days after the appearance of the first fruit cluster on the majority of the plants in the treatment plots. The spreader rows were inoculated on 19 June in 1992 and 29 June in 1993.

Fungicide treatments were initiated within 3 days after inoculation of the spreader rows (22 June in 1992 and 29 June in 1993). Fungicide was applied with a hand-held, CO_2-pressurized boom sprayer. Three Tee Jet D3/DC45 hollow cone nozzles (Spraying Systems Co., Wheaton, IL), spaced 46 cm apart, were used. The sprayer delivered 186 L/ha at 104 kPa nozzle pressure.

Leaf wetness and ambient air temperature were recorded with an Omnidata DP223 data recorder (Omnidata International, Logan, UT). The sensors were placed approximately 25 cm above the ground within one of the spreader rows in the middle of the field.

Individual subplots were harvested when at least 70% of the fruit in the subplot were ripe. The percentage of fruit with anthracnose lesions from each subplot was recorded as previously described.

Linear regression techniques were used to define and test the relationship between the timing of fungicide applications according to accumulated DSV and the disease response for each cultivar. The disease response (percentage of fruit with anthracnose) was regressed on action threshold defined by DSV. The regression line was adjusted to intersect the origin so that the relationship for each cultivar was defined only by its slope, designated as the TOM-CAST anthracnose coefficient (TAC). The cultivar-specific TAC values were then regressed against their corresponding log-transformed RI values. This simple association between cultivar resistance and TAC was used to estimate optimum action thresholds for cultivars and breeding lines included in the anthracnose nursery.

Additional field experiments were conducted in 1992 and 1993 at the Purdue O'Neall Horticultural Research Center to test the relationship between TAC and RI values. These field plots involved cultivars (Table 2) that were included in the anthracnose nursery, but were not used to develop the regression model. Design, preparation, and maintenance of the field plots were similar to those described previously. Fungicide sprays were applied according to calendar-based application schedules or the TOM-CAST program using 12, 16, 20, 24, and 32 DSV action thresholds. TAC values were calculated for each cultivar based on the disease percentages recorded for each treatment.

RESULTS

Disease evaluations and RI-value determinations were made in the

Table 1. Number of sprays applied for each fungicide application interval in field plot experiments in 1992 (experiment I) and 1993 (experiments II and III)

	Field experiment	
Application interval	I	II and III
7-day	13	12
10-day[a]	9	8
14-day[a]	7	6
TOM-CAST 12 DSV[b]	11	12
TOM-CAST 16 DSV	8	9
TOM-CAST 20 DSV	7	7
TOM-CAST 24 DSV	6	6
TOM-CAST 32 DSV	4	5
No fungicide	0	0

[a]Treatment not included in field experiment III.
[b]Daily Severity Values.

Table 2. Observed and predicted TOM-CAST (TAC)[a] anthracnose coefficient values for selected tomato cultivars

Tomato cultivar	Year	Observed TAC[b]	Predicted TAC[c]
88B147	1993	0.130 ± 0.063[d]	0.136
Purdue 9130	1993	0.323 ± 0.081	0.624
OX-38	1993	0.633 ± 0.112	0.822
SO-24	1993	0.858 ± 0.132	0.927
Purdue 861	1993	0.906 ± 0.091	0.862
Ohio 7983	1993	1.320 ± 0.140	1.023
Purdue 861	1992	0.704 ± 0.234	0.879
Ohio 7983	1992	0.869 ± 0.269	0.946

[a]Slope of the regression of percentage of fruit with anthracnose lesions on action threshold (daily severity values). Regression lines were forced through the origin. Cultivars used to test relationship described in Fig. 2.
[b]Determined from field plot experiments in 1992 and 1993.
[c]Obtained by substituting log 10 transformed resistance index values into the expression defined in Fig. 2.
[d]Confidence interval at $P = 0.01$.

anthracnose nursery from 1991 to 1993. Twenty-two cultivars were evaluated in the anthracnose nursery for more than 1 yr. A list of RI values for selected cultivars (except for breeding lines that were evaluated for only 1 yr and are not included in the table) is shown in Table 3. The consistency of cultivar rank based on disease incidence in the nursery was tested by Spearman's coefficient of rank correlation (21). Rank comparisons of twenty-one cultivars evaluated in both 1992 and 1993 were consistent with a t value of 3.46. The consistency of RI values for each cultivar was tested by regression of RI values of 1 yr on RI values of a second year for cultivars included in both years. Twenty-one pairs of RI values were tested for 1992/1993, thirteen pairs for 1991/1993, and twelve pairs for 1991/1992. The coefficients of correlation were 0.62, 0.86, and 0.70 respectively. The slopes of all three regression lines were not significantly different from 1 and the intercepts were not significantly different from 0.

Treatments for the fungicide application interval experiments are described in Table 1. Analysis of variance showed that differences in the incidence of fruit infection among fungicide application intervals and among cultivars were highly significant ($P = 0.0001$) in all three experiments. The incidence of fruit infection increased as fungicide application intervals increased with a few exceptions at the shortest application intervals in the field experiments (Fig. 1). Within each application interval, susceptible cultivars (Ohio 7814 and Ohio 8550) generally had a significantly higher incidence of disease than those considered resistant (Ohio 8245, Hypeel 696, and SO-12). Statistical analysis of transformed disease proportions showed significant differences between cultivars only for the 24 and 32 DSV treatments in experiment I. Statistical differences among cultivars were shown for all fungicide application intervals in experiments II and III.

The TAC values, determined by regression of percentage of fruit anthracnose on application interval, ranged from 0.355 to 1.668 (Table 4). The rank of cultivars, with respect to their TAC values, remained the same for all three field experiments and was the same as the rank of cultivar resistance measured in the anthracnose nursery (except for Ohio 7814 and Ohio 8550 in 1992). Pairwise comparisons showed significant differences in 1992 TAC values between Ohio 8550 and the two lowest cultivars, and between Ohio 8245 and Ohio 7814. Pairwise comparison of TAC values within both 1993 experiments showed significant differences between all TAC values except Hypeel 696 and SO-12.

The relationship between the TAC and RI values was defined by the expression: $TAC = 0.97 + 0.61 \times \text{Log}_{10}(RI)$ (Fig. 2). The coefficient of determination for the regression was 0.55.

To test the regression model, TAC values were generated for cultivars that were not used to develop the above equation. Data from six cultivars in 1993 and two cultivars in 1992 were included in the test (Table 2). The ranking of the cultivars each year by RI values was the same as the ranking of the cultivars according to TAC values except for SO-24 and Purdue 861 in 1993 (SO-24 had a lower observed TAC value but higher RI than Purdue 861). The observed TAC values from the field validation experiments were then compared with the TAC values estimated by the equation. Determination of confidence intervals showed no statistical difference between five of the experimental TAC values and the corresponding TAC values generated by the equation (Table 2). The regression of predicted against observed TAC values resulted in a linear expression ($y = 0.29 + 0.68x$, $R^2 = 0.77$) whose slope was not significantly different from 1 and whose intercept was not significantly different from 0.

Calculating optimum threshold values. Because the TAC value represents the relationship between the fungicide application threshold (DSV) and disease percentage, an optimum action threshold (DSV) can be estimated by dividing the acceptable level of infection by the estimated TAC value. The average percentage of fruit with anthracnose lesions

Table 3. List of resistance index (RI) values of selected tomato cultivars evaluated in the anthracnose nursery at the Purdue O'Neall Horticultural Research Center in Lafayette, IN

	Year		
Cultivar	**1991**	**1992**	**1993**
Ohio 8245	0.380[a]	0.169	0.100
Ohio 8550	1.244	0.932	1.214
Ohio 8556	...	1.609	0.951
Ohio 7814	1.000	1.000	1.000
Ohio 7983	...	0.914	1.223
Hypeel 696	0.502	0.255	0.229
Purdue 9130	...	...	0.271
Heinz 8927	...	...	0.321
Heinz 9201	...	...	0.364
Peto 2196	...	0.431	0.364
Peto 9543	1.606	...	0.714
Purdue 861	...	0.708	0.666
OX-1	...	1.425	0.794
OX-4	...	0.852	1.209
OX-38	...	...	0.571
88 B147	0.054	0.163	0.043
88 B231	1.000	0.748	0.900
SO-12	...	1.978	0.666
SO-15	...	...	0.551
SO-24	...	...	0.851
SO-48	...	...	0.851
Murrieta	1.810	0.655	1.280
PBL 91-30	0.240	0.231	0.151
PBL 91-34	0.928	0.892	0.729
PBL 91-35	0.584	0.646	0.514
PBL 91-36	0.697	0.717	0.329
PBL 91-37	0.241	0.502	0.386
PBL 91-46	...	0.031	0.051
PBL 91-48	...	0.123	0.323

[a]Values were determined by dividing percentage of fruit with anthracnose lesions (mean of 4 replications) by percentage of fruit with anthracnose lesions on a standard susceptible cultivar, Ohio 7814. Actual percentage of fruit with anthracnose lesions on Ohio 7814 was 22.1% in 1991, 32.5% in 1992 and 35.0% in 1993.

Table 4. TOM-CAST anthracnose coefficients[a] for tomato cultivars evaluated in field plot experiments in 1992 and 1993

	Field experiment		
Cultivar	**I[b]**	**II[c]**	**III[c]**
Ohio 8245	0.578 ± 0.053[d]	0.444 ± 0.026	0.355 ± 0.020
Hypeel 696	0.690 ± 0.060	0.617 ± 0.045	0.493 ± 0.035
SO-12	...	0.630 ± 0.048	0.526 ± 0.030
Ohio 7814	0.796 ± 0.075	0.896 ± 0.052	0.892 ± 0.043
Ohio 8550	0.940 ± 0.078	1.668 ± 0.116	1.077 ± 0.042

[a]Slope of regression of percentage of fruit with anthracnose lesions on action threshold (daily severity values). Regression lines were forced through the origin.
[b]Experiment was conducted in 1992.
[c]Experiment was conducted in 1993.
[d]Standard error of mean.

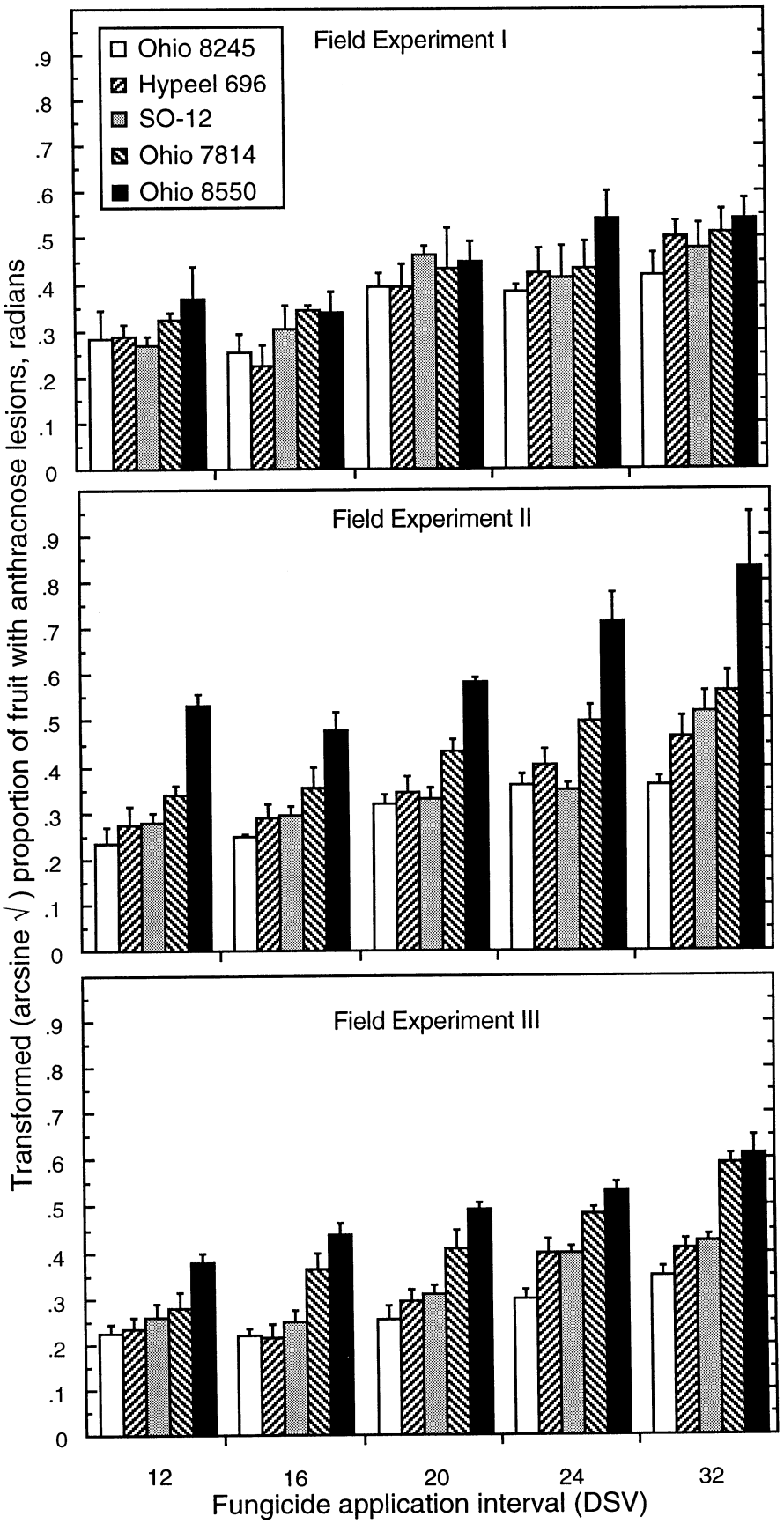

Fig. 1. Mean of transformed proportions of fruit with anthracnose lesions (arcsine [square root]) on five tomato cultivars at five different fungicide application schedules determined by TOM-CAST in 1992 and 1993. Treatments differed in action threshold value used to determine interval between sprays. Vertical bars represent standard errors.

on Hypeel 696 at the 10-day interval was 13.5, which was used to represent the acceptable level of disease incidence at the artificially high inoculum levels of the field experiments. Therefore, the optimum action threshold value for each cultivar was defined as the action threshold value at which the level of fruit infection was estimated to be at 13.5%. For example, optimum action threshold values of 14, 18, and 27 would be calculated for cultivars with estimated TAC values of 1.00, 0.75, and 0.50 respectively (Fig. 3). A partial list of TAC and optimum action threshold values estimated from RI values of cultivars evaluated in the anthracnose nursery is shown in Table 5.

Table 5 also shows the estimated number of sprays for each cultivar for the years 1991–1993. The estimated number of sprays was determined by dividing the cumulative DSV values between spray initiation and harvest for each year by the estimated optimum threshold value.

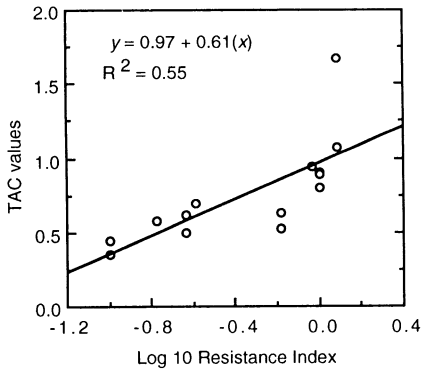

Fig. 2. Effect of cultivar resistance on TAC values. Individual points represent observed TOM-CAST anthracnose coefficient (TAC) values from field experiments conducted in 1992 and 1993. The expression $y = 0.97 + 0.61 \times \mathrm{LOG}_{10}(x)$ estimates TAC values for cultivars with various levels of resistance as defined by the resistance index (RI).

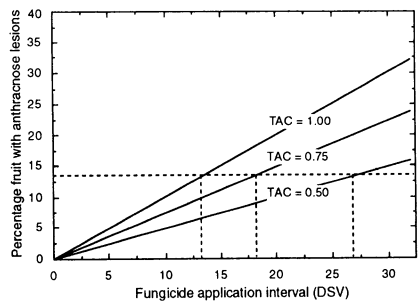

Fig. 3. Theoretical disease responses in artificially inoculated field plots for cultivars estimated to have TOM-CAST anthracnose coefficient (TAC) values of 1.00, 0.75, and 0.50. The broken horizontal line represents the highest acceptable disease incidence (13.5%) based on 10-day spray interval of Hypeel 696. Estimated optimum action threshold values are shown by broken vertical lines as 13, 18, and 27 daily severity values (DSV) for TAC values of 1.00, 0.75, and 0.50 respectively.

Apart from the two most resistant cultivars, the estimated number of fungicide applications ranged from four to seven in 1991, six to ten in 1992, and six to eleven in 1993. The majority of the cultivars had fewer sprays estimated for 1991 and 1992 than the 10-day interval (seven and nine sprays for 1991 and 1992, respectively). In 1993, the majority of the cultivars had an estimated number of sprays that was equal to or greater than the 10-day interval (eight sprays). Very high optimum action threshold values were estimated for PBL 91-46 and 88B147. Only one or two fungicide applications would have been recommended for PBL 91-46 from 1991–1993.

DISCUSSION

Research that combines host resistance and fungicide application schedules on other crops uses parameters such as apparent infection rate or area under disease progress curve to quantify the host resistance component (9,14,16). The determination of such values involves several disease assessments during the growing season. However, repeated assessments for tomato anthracnose are not possible since *C. coccodes* infections remain latent until the fruit ripens (6,11). Therefore, quantification of host resistance is based on a single evaluation at the end of the season. As with foliar diseases, final disease ratings of fruit can be used for evaluating the effects of fungicide applications and resistance if the epidemic has not progressed close to completion (9).

Since the stage of fruit maturity can have a large influence on observed disease incidence, each plot was evaluated at a standard stage of fruit development. The stage at which 70% of the fruit were ripe was judged to be the optimum time for evaluating the plots for disease incidence as there is a low percentage of immature and overripe fruit at this point. In this research most of the plots ranged from 70 to 90% ripe fruit when harvested since visual estimations were not precise and the difference between 70 and 90% ripe fruit in a plot was often only 1 or 2 days. This was not critical since no relationship between fruit maturity and disease incidence was evident when this range occurred among the four replications of a cultivar. However, in a few cases in which the percentage of ripe fruit in a plot at harvest was 95% or greater, a higher incidence of anthracnose was consistently observed for those plots than for plots of the same cultivar with a lower percentage of ripe fruit.

RI values were consistent for most cultivars. However, large differences were observed between 1992 and 1993 for several cultivars, particularly Ohio 8556, OX-1, and SO-12. Due to delays caused by rain in 1992, all replications of these three cultivars were harvested when 95% or more of the fruit were ripe. The advanced stage of fruit maturity was probably the main factor that produced much higher RI values in 1992 than in 1993.

According to the TOM-CAST program, initial fungicide applications are made when severity values have accumulated to a predetermined threshold value based on the premise that it is not necessary to spray until the initial inoculum builds up to a certain level (13). In our field experiments the application of the millet seed inoculum in the spreader rows created a high level of inoculum pressure independent of the factors measured by the TOM-CAST program. Therefore, fungicide sprays were initiated about the same time that the inoculum was applied. Preliminary research indicates that infections by *C. coccodes* on immature fruit are more successful in developing into lesions on susceptible cultivars than on resistant cultivars (4). Future research may consider the relationship between host resistance and the optimum threshold for initiating fungicide sprays to further improve the TOM-CAST program.

Based on statistical analysis, three of the eight TAC values used to test the regression equation were significantly different from estimated TAC values. However, TAC values were determined from regression lines forced through the origin. This procedure created a standard error much smaller than the standard error of the least squares regression even though the latter represented the best fit among the actual data points. The regression of predicted TAC on actual TAC values indicated that the relationship between TAC and RI values was adequately described by the regression model defined in Fig. 2.

The 13.5% fruit with anthracnose lesions that was used to calculate optimum action threshold values for specific cultivars would be unacceptable in com-

Table 5. Average resistance index (RI) values, estimated TOM-CAST anthracnose coefficient (TAC) values, optimum thresholds, and number of fungicide sprays of selected tomato cultivars evaluated in the anthracnose nursery at the Purdue O'Neall Horticultural Research Center in Lafayette, IN

Cultivar or breeding line	Average RI[a]	Estimated TAC value[b]	Estimated optimum threshold value[c]	Estimated number of fungicide sprays[d]		
				1991	1992	1993
PBL 91-46	0.041[e]	0.124	109	1	2	2
88 B147	0.087[f]	0.323	42	3	3	4
PBL 91-30	0.207[f]	0.553	24	4	6	6
Ohio 8245	0.216[f]	0.563	24	4	6	6
PBL 91-48	0.223[e]	0.572	24	4	6	6
Purdue 9130	0.271[g]	0.624	22	4	6	7
Heinz 8927	0.323[f]	0.671	20	5	7	7
Hypeel 696	0.329[f]	0.675	20	5	7	7
Peto 2196	0.399[e]	0.726	19	5	7	8
Heinz 9201	0.366[g]	0.704	19	5	7	8
PBL 91-37	0.376[f]	0.711	19	5	7	8
SO-15	0.551[g]	0.812	17	6	8	8
OX-38	0.571[g]	0.822	16	6	8	9
PBL 91-35	0.581[f]	0.826	16	6	8	9
PBL 91-36	0.581[f]	0.826	16	6	8	9
SO-12	0.666[g]	0.862	16	6	8	9
Purdue 861	0.687[e]	0.871	15	6	9	10
OX-1	0.794[g]	0.909	15	6	9	10
PBL 91-34	0.850[f]	0.927	15	6	9	10
SO-24	0.851[g]	0.927	15	6	9	10
SO-48	0.851[g]	0.927	15	6	9	10
88 B231	0.883[f]	0.937	14	7	9	10
Ohio 8556	0.951[e]	0.957	14	7	9	10
Ohio 7814	1.000[f]	0.970	14	7	9	10
OX-4	1.031[e]	0.978	14	7	9	10
Ohio 7983	1.069[e]	0.988	14	7	9	10
Ohio 8550	1.130[f]	1.002	13	7	10	11
Peto 9543	1.160[h]	1.009	13	7	10	11
Murrieta	1.248[f]	1.029	13	7	10	11

[a] Values were determined by dividing percentage of fruit with anthracnose lesions by percentage of fruit with anthracnose lesions on Ohio 7814.
[b] Determined by substituting log-transformed RI values into the regression model described in Fig. 2.
[c] Determined by dividing 13.5, the average percentage of fruit with anthracnose lesions on Hypeel 696 at the 10-day application interval in experiments I and II, by the estimated TAC value.
[d] Determined by dividing the total cumulated daily severity values between initiation of fungicide application and harvest (87 in 1991, 123 in 1992, and 134 in 1993) by the estimated optimum threshold value.
[e] Average of data from 1992 and 1993.
[f] Average of data from 1991, 1992, and 1993.
[g] 1993 data only.
[h] Average of data from 1991 and 1993.

mercial production. However, a 10-day spray interval would provide adequate control under natural situations. We presumed that the average of 13.5% fruit with anthracnose lesions for the 10-day interval under the artificially high disease pressure of our field experiments would be comparable with an acceptable level under natural conditions.

Action thresholds calculated according to the regression equation indicate that higher thresholds may be used for some cultivars than have been previously recommended. Optimum action threshold values from 16 to 20 DSV have been recommended for the TOM-CAST system (10,18). The equation predicts very high optimum action threshold values (109 and 42) for cultivars resistant to anthracnose such as PBL 91-46 and 88B147. As a result, very few fungicide applications for anthracnose control would be made for such cultivars even in years very favorable for disease development. While few sprays may adequately control anthracnose on such cultivars, yield may be reduced due to high levels of foliar diseases (10). Weather-based fungicide scheduling programs may be adjusted by altering the interval between sprays or the timing of the initial spray to avoid serious epidemics of other diseases (20).

The relationship between host resistance and fungicide application intervals should be applicable to processing tomato cultivars used in the midwestern and northeastern production regions of the U.S. The average predicted optimum threshold value for cultivars evaluated in the anthracnose nursery (excluding PBL 91-46 and 88B147) was within the range of optimum threshold values currently used in Indiana. RI values for cultivars should be determined in the region for which they are adapted.

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