BLIGHT-ALERT: A Weather-Based Predictive System for Timing Fungicide Applications on Onion Before Infection Periods of *Botrytis squamosa*

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ABSTRACT

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A weather-based predictive system named BLIGHT-ALERT was developed for timing applications of protectant fungicides to control Botrytis leaf blight of onion after it has reached the critical disease level (CDL) of 1.0 lesion/leaf and after the first fungicide spray has been applied. The system incorporates two components to forecast infection periods of *Botrytis squamosa*: a model called the inoculum production index (*IPI*), which forecasts the production of inoculum by *B. squamosa* based on temperature, relative humidity, and crop development; and National Weather Service forecasts of precipitation probability (*PP*), which have been associated with conditions favorable for infection of onion leaves by *B. squamosa*. Field experiments were conducted in commercial onion fields in New York from 1985 through 1987 in which the fungicide was first applied at the CDL in all treatments and subsequent applications were made according to *IPI* forecasts, *PP* forecasts, and combinations of these. Use of either the *30-IPI* treatment ($PP \geqslant 30\%$ and an *IPI* forecasting concurrent sporulation) or the $30\text{-}IPI_2$ treatment (incorporating crop age rather than calendar date) for timing fungicide applications resulted in two to three fewer applications each season as compared to a weekly spray program. These timed treatments controlled Botrytis leaf blight as effectively as did the weekly spray program. We conclude that the $30\text{-}IPI_2$ treatment (BLIGHT-ALERT) can be used as a predictive system for forecasting infection periods of *B. squamosa* on onion, thereby warning of periods when fungicide protection may be necessary after the CDL has been reached and the first fungicide spray has been applied.

Botrytis leaf blight of onion (*Allium cepa* L.) currently is controlled in New York primarily through the use of protectant fungicides applied on a weekly basis (19). Although control of this disease is necessary to achieve satisfactory yields in commercial onion production, adequate disease control often can be achieved during periods unfavorable for disease development with the use of fewer fungicide applications than are used in a regular spray program (27,31). Because of environmental, public health, economic, and farm-management considerations concerning unnecessary fungicide use, methods should be developed for timing fungicide applications that provide acceptable control of Botrytis leaf blight while reducing the frequency of fungicide use when possible.

New York onion growers currently are advised to begin fungicide spray programs when Botrytis leaf blight reaches the critical disease level (CDL) of 1.0 lesion/leaf (20,27), which provides growers with a warning that *Botrytis squamosa* Walker (anamorph of *Botryotinia squamosa* Viennot-Bourgin) is present at potentially damaging levels. This action threshold currently is implemented as part of Cornell University's Onion Integrated Pest Management (IPM) program (3). Another predictive system called BOTCAST (31) is available which also times the initiation of a fungicide program based on the accumulation of a critical number of weather-based disease severity units. Neither of these systems considers proper timing of subsequent applications.

Several studies have been conducted in which fungicide applications for control of Botrytis leaf blight were scheduled throughout the season according to forecasts of expected rainfall (8) or expected leaf wetness duration (32,34). The fungicide timing programs evaluated in these studies were based only on forecasts of conditions favoring infection and did not include forecasts of inoculum production by the pathogen. A predictive system has been developed for *B. squamosa* that schedules fungicide applications throughout the season by forecasting spore episodes of the pathogen (17). Although this model was reliable for predicting spore episodes in some regions (17), it did not forecast 44% of the spore episodes recorded with a Hirst spore trap located in a commercial onion field in New York (37). A recently developed simulation model for Botrytis leaf blight was accurate in modeling the development of leaf blight in experimental onion plots in Michigan (1). However, this simulation model currently is not designed to issue recommendations for timing of fungicide applications. We concluded that an alternative predictive system was necessary for timing fungicide applications to control Botrytis leaf blight of onion after it has reached the CDL.

Satisfactory control of Botrytis leaf blight should be possible if fungicide is present on onion leaves when it will interrupt secondary infection cycles of *B. squamosa*. Because effective fungicides with therapeutic activity presently are unavailable for control of the disease, available protectant fungicides must be applied before infection occurs. To achieve this in a predictive system, infection periods of *B. squamosa* must be identified before their occurrence. Previous research has led to the development of models for forecasting sporulation (37) and infection (38) by *B. squamosa* in commercial onion fields in New York, the two principal events in a secondary infection cycle of this pathogen (28,33). Sporulation is forecasted by a model (37) that uses temperature, relative humidity, and an estimate of crop development to issue a daily inoculum production index (*IPI*), an index that indicates the likelihood of sporulation occurring during the next 24-hr period. Conditions favorable for severe infection of onion leaves by conidia of *B. squamosa* can be forecasted by a National Weather Service precipitation probability (*PP*) of at least 30% (38). The objective of the present study was to evaluate fungicide timing treatments based on *PP* and *IPI* forecasts in field trials located in commercial onion fields in New York.

MATERIALS AND METHODS

Cultural conditions and experimental design. Field experiments were conducted in commercial onion fields in Orange County, NY, where all cultural operations except application of fungicides and insecticides were performed by the grower-cooperator. Four-row beds (38-cm row spacing) were divided into plots measuring 1.5 × 6.6 m. The field plots were arranged in a randomized complete block design, with each of five continuous beds comprising a block. The initial fungicide application was made to all treatment plots in an experiment when the CDL of 1.0 lesion/leaf was reached in that field. Subsequent fungicide applications were made according to a weekly schedule and according to timing schedules based on *PP* and *IPI* forecasts. To reduce interplot interference (11,26), an area measuring 6.6 × 6.9 m that received no fungicide was located at least 10 m to the northeast of the treatment areas. Data from these unsprayed plots were not included in statistical analyses.

Fungicide and insecticide were appied with a CO_2-powered, four-row backpack sprayer delivering 935 L of water per hectare at 140–170 kPa through hollow cone nozzles (D-4 nozzles with No. 25 whirl plates, Spraying Systems Co., Wheaton, IL). The insecticide diazinon (Diazinon AG500) was applied weekly at the rate of 0.55 kg a.i./ha to all plots for control of onion thrips (*Thrips tabaci* Lindeman). In 1987, permethrin (Ambush 2E) at 0.22 kg a.i./ha was substituted for diazinon in all plots after 11 July.

Assessment of treatment effects and data. Disease severity was assessed at 4- to 10-day intervals beginning approximately 90 days after planting. Using standard area diagrams for comparison, each plot was rated on a 0–18 scale (18) representing 0–100% diseased foliage. On each sampling date, two disease ratings taken independently were made for each plot and then averaged. The area under the disease progress curve (AUDPC), a time-weighted measure of disease severity, was calculated for each plot (35).

Yield data were collected from each plot by trimming the leaves from bulbs taken from the middle 5.5 m of the two inner rows of each plot and then weighing the bulbs harvested. AUDPCs, arcsine-transformed (30) final disease severities, and yields were evaluated by analysis of variance, and appropriate linear contrasts were tested for statistical significance.

1985 experiment. A field experiment was conducted in 1985 in which eight treatments were tested. The first fungicide application was made on all plots when the CDL of 1.0 lesion/leaf was reached. For subsequent fungicide applications, the treatments tested were as follows: a weekly spray schedule; a treatment designated *30*, in which fungicide was not applied until the *PP* was at least 30% during the next 36 hr; a treatment designated *50*, in which fungicide was not applied until the *PP* was at least 50% during the next 36 hr; a *70* treatment, in which fungicide was not applied until the *PP* was at least 70% during the next 36 hr; an *IPI* treatment, in which fungicide was not applied until a forecast for sporulation was issued by the *IPI* model; and treatments designed *30-IPI*, *50-IPI*, and *70-IPI*, in which fungicide was not applied until the *IPI* model forecasted sporulation and, on the same day, the *PP* was at least 30, 50, and 70%, respectively. In all eight treatments, fungicide sprays were assumed to provide at least 7 days of protection from infection by *B. squamosa*, so that in each treatment fungicide was not applied until at least 7 days had elapsed since the previous application, regardless of forecast conditions.

PP forecasts were taken from National Weather Service forecasts broadcasted daily on WXL 37 (162.475 MHz). *IPI* forecasts were made using a model described previously (37). Weather data were collected using a hygrothermograph within a standard weather shelter (37) and a rain gauge (38). Leaf wetness was monitored as previously described (38). The weather shelter containing the hygrothermograph was located in a commercial onion field at Nowak Farms (Florida, NY) in 1985 and 1986 and at Sidoti Farms (Pine Island, NY) in 1987. Rain gauges were placed at each location where experiments were conducted.

Because the *IPI* model forecasts the likelihood of spore production by *B. squamosa* but not spore survival from previous forecast periods, the following decision rule was employed in implementing the *IPI* model. Inoculum was forecasted as being present on a particular day if the *IPI* for that day was at least 7 (indicating that sporulation was expected that day) (37) or if spores forecasted in a previous forecast period survived to the current forecast period. Based on research by Alderman et al (2), spores of *B. squamosa* were assumed to survive until at least 5 hr of leaf wetness had occurred.

The experiment was located in a field (Field A, Sidoti Farms, Pine Island, NY) planted on 4 April 1985 to the cultivar Sentinel. The field was 6.4 km to the southwest of the weather shelter on a contiguous area of organic soil. The fungicide used in all treatments was iprodione (Rovral 50WP) at 0.84 kg a.i./ha until 12 July 1985 and at 1.12 kg a.i./ha thereafter. The spreader-sticker Triton B-1956 was included at 0.44 L/ha in all applications. Disease assessments and yield measurements were made as described above.

1986 experiment. Results from 1985 identified treatments that were ineffective in controlling Botrytis leaf blight under severe disease pressure. Therefore, only treatments effective in controlling the disease in 1985 were evaluated in 1986. After all plots received the first fungicide application at the CDL, subsequent applications were made according to the following schedules: weekly; *30* (described above); IPI_2, in which fungicide was not applied until a forecast for sporulation was issued by the IPI_2 model; and $30\text{-}IPI_2$, in which fungicide was not applied until the IPI_2 model forecasted sporulation and, on the same day, the *PP* was $\geqslant$30%. The IPI_2 model is a slightly improved version of the *IPI* model in which sporulation forecasts are based on crop age rather than calendar date (37). As in 1985, fungicide was not applied until at least 7 days had elapsed since the previous application.

The above treatments were tested in two locations: Field A (Sidoti Farms, Pine Island, NY, 6.4 km to the southwest of the weather shelter), planted to cultivar Sentinel on 10 April 1986; and Field B (Korycki Farms, Florida, NY, 100 m from the weather shelter), planted to cultivar Spartan Banner 80 on 11 April 1986. A mixture of iprodione at 0.56 kg a.i./ha and maneb + Zn (Dithane FZ 4F) at 2.69 kg a.i./ha was used for all fungicide applications in all treatments.

1987 experiment. Data collected in 1986 revealed the importance of accounting for fungicide weathering in timing fungicide applications for control of Botrytis leaf blight. Therefore, in addition to the weekly, *30*, and *30-IPI*$_2$ treatments, a *30-IPI*$_2$*-wthr* treatment was evaluated in 1987. In the last treatment, fungicide applications after the initial application were made when there was at least a 30% chance of rain, the *IPI*$_2$ model predicted inoculum production, and the fungicide residue from the previous application had weathered significantly. Weathering of the iprodione/mancozeb mixture used in 1987 was estimated using the following decision rule (36): The iprodione/mancozeb mixture was effective for at least 3 days and until at least 1.75 cm of rain had been recorded or until 12 days had elapsed since application.

The above treatments were tested at two locations: Field A (Sidoti Farms, Pine Island, NY, at which the weather shelter was located), planted to cultivar Sentinel on 11 April 1987; and Field C (Paffenroth Farms, Pine Island, NY, 1.6 km to the south of the weather shelter), planted to cultivar Spartan Banner 80 on 14 April 1987. A mixture of iprodione at 0.56 kg a.i./ha and mancozeb (Dithane F-45 4F) at 2.69 kg a.i./ha with Triton B-1956 included at 0.44 L/ha was used in all treatments.

RESULTS

1985 experiment. The 1985 growing season was characterized by high Botrytis leaf blight pressure throughout most of the season in the Orange County onion production area, and this is reflected in the high AUDPC and low yield of untreated control plots relative to plots treated weekly with fungicide (Table 1). From four to nine fungicide applications were required in the timed fungicide treatments (Table 1). AUDPCs, final disease severities, and yields of the timed treatments differed among the treatments tested (Table 1).

The *30*, *IPI*, and *30-IPI* treatments were effective in controlling Botrytis leaf blight in 1985 with nine, eight, and seven sprays, respectively, as compared to nine sprays in the weekly spray program (Table 1). There were significantly ($P < 0.01$) higher AUDPCs and final disease severities in treatments in which fungicide was not applied until *PP* was 50% or more (Tables 1 and 2), reflecting poor disease control in the *50*, *70*, *50-IPI*, and *70-IPI* treatments. Significantly ($P < 0.01$) lower yields also were associated with these treatments (Tables 1 and 2). A significant ($P < 0.05$) *IPI* effect was observed for the AUDPC and final disease severity, and a significant ($P < 0.05$) interaction of (0, 30 vs. 50, 70) × *IPI* was found in final severity. Significantly better disease control was obtained in the *30-IPI* treatment with only seven sprays than in the *50* treatment with eight sprays (Table 1), indicating the importance of proper timing of fungicide applications for controlling the disease.

1986 experiment. Disease pressure in 1986 was light until late July when an intense period of wet weather caused a sharp increase in disease development. As a consequence, development of Botrytis leaf blight was moderate at both experimental locations. All three timed treatments tested in 1986 resulted in fewer sprays than the weekly spray program, with eight, seven, and six sprays in the *30*, *IPI*$_2$, and *30-IPI*$_2$ treatments, respectively (Table 3). At Field A, slightly but significantly ($P < 0.01$) greater disease development was observed in the *IPI*$_2$ and *30-IPI*$_2$ treatments than in the weekly and *30* treatments (Tables 3 and 4). However, this difference did not result in a yield loss in these treatments, as evidenced by the lack of significant *IPI*$_2$ or *IPI*$_2$ × location effects on yield (Table 4).

Although the slight loss in efficacy of the *IPI*$_2$ and *30-IPI*$_2$ treatments at Field A did not affect yield, it was important to document what led to this reduction in disease control. Rainfall records collected during the experiment documented that 8.9 cm of rainfall occurred within 12 hr of applying fungicide to the *IPI*$_2$ and *30-IPI*$_2$ treatments at Field A, probably removing most of the foliar fungicide residue. During the following 6-day period, sporulation of *B. squamosa* was forecasted daily by the *IPI* model and observed in the field plots, and numerous leaf wetness episodes were recorded that were of sufficient duration to permit moderate to severe levels of infection (38). During this 6-day period with numerous moderate and severe infection periods, the weekly and

TABLE 2. Mean squares for measures of disease development and yield in treatments for timing fungicide applications to control Botrytis leaf blight of onion in 1985

Source of variation[a]	df	Mean squares[b] AUDPC[c]	Final disease severity[d]	Yield
Blocks	4	0.77	4.7	98.4**
Precipitation probability (*PP*)	3	9.62**	479.6**	52.7*
0, 30 vs. *50, 70*	1	25.32**	1322.5**	131.4**
0 vs. *30*	1	0.61	5.0	0.9
50 vs. *70*	1	2.94**	111.4*	25.9
Inoculum production index (*IPI*)	1	1.12*	67.1*	3.0
PP × *IPI*	3	0.48	31.8	7.1
(*0, 30* vs. *50, 70*) × *IPI*	1	0.60	67.1*	4.6
(*0* vs. *30*) × *IPI*	1	0.27	5.5	15.8
(*50* vs. *70*) × *IPI*	1	0.57	22.9	1.1
Residual	28	0.26	14.6	14.7

[a] Unsprayed plots excluded from statistical analysis.
[b] Mean squares producing *F*-ratios with significance levels of $P < 0.05$ and $P < 0.01$ are denoted by * and **, respectively.
[c] Area under the disease progress curve.
[d] Proportions of diseased tissue were arcsine-transformed before analysis.

TABLE 1. Disease development and yield in treatments for timing fungicide applications to control Botrytis leaf blight of onion in 1985

Spray schedule[a]	Fungicide applications (no.)	AUDPC[b]	Final disease severity (%)	Yield (kg/plot)
Weekly	9	2.48 (± 0.22)[c]	35 (± 2)	27.2 (± 0.7)
30	9	1.90 (± 0.09)	31 (± 2)	28.2 (± 1.0)
50	8	3.81 (± 0.36)	55 (± 2)	26.2 (± 0.6)
70	4	4.24 (± 0.29)	59 (± 4)	25.4 (± 1.4)
IPI	8	2.16 (± 0.24)	33 (± 1)	27.4 (± 1.0)
30-IPI	7	2.04 (± 0.25)	33 (± 3)	26.9 (± 1.1)
50-IPI	7	2.89 (± 0.30)	42 (± 4)	26.4 (± 1.0)
70-IPI	4	4.00 (± 0.20)	54 (± 3)	25.2 (± 1.2)
Untreated	0	11.51	97	21.5

[a] *30*, *50*, and *70* indicate minimum precipitation probabilities (*PP*) (30, 50, and 70%, respectively) that trigger a fungicide application, given that 7 days have elapsed since the previous application, and *IPI* indicates that a forecast of inoculum production triggers an application, given that the *PP* condition has been met.
[b] Area under the disease progress curve (proportion-days).
[c] Mean (± standard error).

TABLE 3. Disease development and yield in treatments for timing fungicide applications to control Botrytis leaf blight of onion in 1986

Location	Spray schedule[a]	Fungicide applications (no.)	AUDPC[b]	Final disease severity (%)	Yield (kg/plot)
Field A	Weekly	9	2.11 (± 0.16)[c]	21 (± 2)	21.6 (± 2.5)
	30	8	2.04 (± 0.14)	24 (± 2)	22.3 (± 2.9)
	IPI$_2$	7	2.43 (± 0.21)	29 (± 1)	21.7 (± 2.1)
	30-IPI$_2$	6	2.61 (± 0.11)	30 (± 1)	22.3 (± 2.7)
	Untreated	0	6.53	65	19.1
Field B[d]	Weekly	9	1.92 (± 0.18)	21 (± 1)	25.4 (± 5.8)
	30	8	1.70 (± 0.04)	20 (± 1)	24.8 (± 4.6)
	IPI$_2$	7	1.71 (± 0.16)	20 (± 1)	24.3 (± 3.2)
	30-IPI$_2$	6	1.71 (± 0.10)	20 (± 2)	25.4 (± 5.6)

[a] *30* indicates minimum precipitation probability (*PP*) (30%) that triggers a fungicide application, given that 7 days have elapsed since the previous application, and *IPI*$_2$ indicates that a forecast of inoculum production triggers an application, given that the *PP* condition has been met.
[b] Area under the disease progress curve (proportion-days).
[c] Mean (± standard error).
[d] Data unavailable on disease development and yield in untreated plots.

TABLE 4. Mean squares for measures of disease development and yield in treatments for timing fungicide applications to control Botrytis leaf blight of onion in 1986

Location	Source of variation[a]	df	Mean squares[b] AUDPC[c]	Final disease severity[d]	Yield
Field A	Blocks	4	0.211	12.64*	118.4**
	Precipitation probability (*PP*)	1	0.017	8.84	9.5
	Inoculum production index (IPI_2)	1	0.990**	90.31**	0.0
	$PP \times IPI_2$	1	0.076	2.52	0.0
	Residual	12	0.093	2.87	4.6
Field B	Blocks	4	0.073	3.76	395.8**
	PP	1	0.061	1.25	1.3
	IPI_2	1	0.050	0.80	1.5
	$PP \times IPI_2$	1	0.058	1.15	17.1
	Residual	12	0.090	4.23	27.0

[a] Untreated plots excluded from statistical analysis.
[b] Mean squares producing *F*- ratios with significance levels of $P<0.05$ and $P<0.01$ are denoted by * and **, respectively.
[c] Area under the disease progress curve.
[d] Proportions of diseased tissue were arcsine-transformed before analysis.

30 plots were treated with fungicide and were protected through most of the infection periods. The IPI_2 and *30-*IPI_2 plots, however, remained untreated during this 6-day period because of the decision rule dictating that a spray would not be applied until at least 7 days had elapsed since the previous spray. As a consequence, some uncontrolled infection occurred in the IPI_2 and *30-*IPI_2 plots. A similar scenario did not develop at Field B because only 1.5 cm fell at this site during the original rainfall episode that began this period of rapid disease development, and these plots probably still had sufficient fungicide protection throughout the ensuing 6-day period of high disease pressure.

1987 experiment. Weather during the 1987 growing season included dry periods and periods of very intense thunderstorm activity. Disease pressure was moderate in most areas of Orange County. Because of dry weather early in the growing season, the CDL was reached approximately 1 wk later than in 1985 and 1986. Consequently, only eight sprays were applied in the weekly treatment (Table 5). All three timed treatments called for fewer sprays than the weekly program. Both the *30* and the *30-*IPI_2*-wthr* treatments received a total of seven sprays, although the timing of these differed. The *30-*IPI_2 treatment received a total of six sprays.

Levels of disease control and yields among treatments tested at Field A did not differ significantly (Table 6). Levels of disease at Field C were assessed using a leaf greenness rating (20) because hail

TABLE 5. Disease development and yield in treatments for timing fungicide applications to control Botrytis leaf blight of onion in 1987

Location	Spray schedule[a]	Fungicide applications (no.)	AUDPC[b]	Final disease severity (%)	Leaf greenness[c]	Yield (kg/plot)
Field A	Weekly	8	4.09 (± 0.26)[d]	27 (± 2)	...	14.6 (± 1.2)
	30	7	4.00 (± 0.25)	30 (± 2)	...	14.8 (± 0.7)
	30-IPI_2	6	4.31 (± 0.50)	30 (± 3)	...	14.3 (± 1.1)
	30-IPI_2*-wthr*	7	4.02 (± 0.48)	27 (± 3)	...	15.8 (± 0.8)
	Untreated	0	11.06	88	...	13.7
Field C[e]	Weekly	8	...	...	6.0 (± 0.5)	16.7 (± 0.7)
	30	7	...	...	5.8 (± 0.4)	16.6 (± 0.3)
	30-IPI_2	6	...	...	5.8 (± 0.3)	16.5 (± 0.5)
	30-IPI_2*-wthr*	7	...	...	5.7 (± 0.3)	17.4 (± 0.3)

[a] *30* indicates minimum precipitation probability (*PP*) (30%) that triggers a fungicide application, given that at least 7 days have elapsed since the previous application. *30-*IPI_2 indicates that $PP \geqslant 30\%$ and a forecast of inoculum production trigger an application, given that at least 7 days have elapsed since the previous application. *30-*IPI_2*-wthr* indicates that $PP \geqslant 30\%$, a forecast of inoculum production, and significant weathering of previous spray triggers an application.
[b] Area under the disease progress curve (proportion-days).
[c] 10 = complete leaf greenness and 0 = no leaf greenness.
[d] Mean (± standard error).
[e] Data unavailable on disease development and yield in untreated plots.

TABLE 6. Mean squares for measures of disease development and yield in treatments for timing fungicide applications to control Botrytis leaf blight of onion in 1987

Location	Source of variation[a]	df	Mean squares[b] AUDPC[c]	Final disease severity[d]	Leaf greenness	Yield
Field A	Blocks	4	0.667	9.08	...	50.6*
	Treatment	3	0.097	5.32	...	9.3
	Weekly vs. all others	1	0.002	2.78	...	2.9
	30 vs. (*30-*IPI_2 + *30-*IPI_2*-wthr*)	1	0.088	3.14	...	0.8
	30-IPI_2 vs. *30-*IPI_2*-wthr*	1	0.202	10.00	...	24.0
	Residual	12	0.789	12.63	...	11.9
Field C	Blocks	4	...	...	1.08	8.2
	Treatment	3	...	...	0.08	3.8
	Weekly vs. all others	1	...	...	0.20	0.1
	30 vs. (*30-*IPI_2 + *30-*IPI_2*-wthr*)	1	...	...	0.01	1.8
	30-IPI_2 vs. *30-*IPI_2*-wthr*	1	...	...	0.03	9.5
	Residual	12	...	...	0.59	4.8

[a] Untreated plots excluded from statistical analysis.
[b] Mean squares producing *F*-ratios with significance levels of $P<0.05$ are denoted by *.
[c] Area under the disease progress curve.
[d] Proportions of diseased tissue were arcsine-transformed before analysis.

injury precluded making the repeated disease assessments necessary to calculate the AUDPC. Individual plots were assigned two independently taken disease ratings using a 0–10 scale, where 0 = no green leaves and 10 = complete leaf greenness. The two ratings for each plot were averaged and an analysis of variance was performed. Levels of disease control and yields at Field C were similar among the four treatments (Table 5), and differences in levels of disease and yield were nonsignificant (Table 6).

DISCUSSION

A weather-based predictive system named BLIGHT-ALERT was developed for Botrytis leaf blight of onion. This system forecasts infection periods by forecasting specific events in the life cycle of *B. squamosa*, thus providing a warning of the need for control measures. This approach was researched because warnings to growers to spray following an infection period, a workable approach in many pathosystems (6,7,9,13,15,21), would be untenable for controlling Botrytis leaf blight of onion because of the lack of therapeutic fungicides for this disease. Another approach to timing fungicide sprays for controlling polycyclic fungal pathogens has been to forecast the need for fungicide application based on the accumulation of an empirically determined critical number of disease severity units (12,16,22). Although such an approach has been used successfully in some field experiments (22,23,24), a concern with this approach is that it may require fungicide applications after infections are initiated (10), when protectant fungicides are ineffective. Because of these considerations, the present research has focused on the question of whether Botrytis leaf blight can be controlled by timing applications of protectant fungicides in anticipation of forecasted infection periods.

The most cost-effective fungicide timed treatments in these experiments were the *30-IPI* and *30-*IPI_2 treatments, which were designed to forecast sporulation and infection by *B. squamosa* using an *IPI* or IPI_2 (37) prediction of the presence of inoculum and a $PP \geqslant 30\%$ (38), respectively. These treatments provided good disease control while resulting in two to three fewer fungicide applications than in the weekly spray schedule. These results were highly encouraging, especially since the growing seasons in which these experiments were conducted were all moderately to highly favorable for Botrytis leaf blight. Even greater reductions in fungicide use may be possible during dry seasons. Furthermore, all fungicide timed treatments were compared to a 7-day spray schedule, which served as a control treatment. However, many New York onion growers apply fungicides on a 4- to 5-day schedule during periods when weather conditions are conducive to disease development. In these situations, the use of the *30-*IPI_2 treatment, which we have named BLIGHT-ALERT, could result in greater savings in fungicides in a commercial setting than those observed in the present study.

The principal objective of many predictive systems, including the system developed in this paper, is to provide a rational basis for reducing pesticide use when such use is unnecessary for satisfactory disease management. However, BLIGHT-ALERT also should be of value during weather favorable for *B. squamosa*. By providing forecasts of possible infection periods, the system will warn growers of the need for fungicide protection, thereby reducing the possibility of an uncontrolled outbreak of disease.

Disease control was consistently satisfactory when fungicide sprays were withheld until $PP \geqslant 30\%$. Higher threshold precipitation probabilities were tested in 1985, but uncontrolled infections occurred when sprays were withheld until $PP \geqslant 50\%$. These results indicate that a *PP* of 30% is a threshold above which significant development of Botrytis leaf blight of onion can occur in the Lower Hudson Valley. In a related study (38), leaf wetness periods when $PP < 30\%$ were typically 8–12 hr in duration and resulted from nightly dew periods. Leaf wetness periods of 14 hr or more were recorded only when $PP \geqslant 30\%$, and these longer leaf wetness periods resulted from either rainfall alone or dew periods that were preceded or followed by rainfall (38). The observation in the present study that fungicide sprays were necessary only when $PP \geqslant 30\%$ suggests that leaf wetness periods associated with dew generally are unimportant in the epidemiology of Botrytis leaf blight of onion in the field unless they are extended in duration by a rainfall episode.

The importance of accounting for weathering of protectant fungicides when timing applications was indicated in the 1986 experiments when excessive washoff of fungicide resulted in a slight loss of disease control in the IPI_2 and *30-*IPI_2 treatments at Field A. This did not lead to reduced yield in these treatments, probably because only a slight increase in disease was observed which occurred after significant crop development. However, an equivalent episode of disease increase earlier in the season might have resulted in significant yield loss (4); therefore, a decision rule for estimating fungicide weathering was developed and tested in 1987 as an additional component of the BLIGHT-ALERT predictive system. This decision rule resulted in the application of an additional spray without improvement in disease control. Consequently, the rule as formulated may provide an overly conservative estimate of the level of fungicide protection remaining. Furthermore, additional fungicides and spreader-stickers other than those tested are labeled for use on onion, which complicates any attempt to estimate levels of fungicide protection. Although BLIGHT-ALERT will provide forecasts of impending infection periods of *B. squamosa*, growers should use their judgment and experience in determining if the amount of fungicide remaining on their crop is adequate for protection, at least until more sophisticated models (5,29) can be developed for estimating fungicide residues on onion foliage.

Implementation of the predictive system described here would probably best be accomplished through an IPM program (3) using preprogrammed microcomputers (14) that monitor the required weather data and issue appropriate forecasts. Considerations other than Botrytis leaf blight control play a part in dictating a spray schedule for onions in New York, especially control of other onion pests. An action threshold for thrips on onion is available for New York (25) and is used currently in Cornell University's Onion IPM program. A predictive system has been developed for timing fungicide applications to control onion downy mildew (13) caused by *Peronospora destructor* (Berk.) Casp. Monitoring populations of onion maggot flies (*Hylemya antigua* Meigen) (3) is of value in timing applications of insecticides to control this pest. Combined use of the CDL system and BLIGHT-ALERT with predictive systems for other onion pests should give onion growers a rational basis for applying foliar pesticides.

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