Final Project Report to the NYS IPM Program, Agricultural IPM 2003-2004.

1. Title:
Controlling Powdery Mildew of Pumpkin Using Pre-existing Fungicide Scheduling Programs

2. Project Leader(s):
Tyrone W. Hall
Extension Resource Educator, Commercial Fruit and Vegetable Specialist SCNYAG
Cornell Cooperative Extension – Tioga County
56 Main Street
Owego, NY 13827
Phone: (607) 687-4020 Fax: (607) 687-3619
twh22@cornell.edu

3. Cooperators:
Margaret Tuttle McGrath
Department of Plant Pathology, Cornell University
Long Island Horticultural Research & Extension Center
3059 Sound Avenue
Riverhead, NY 11901-1098
Phone: 631-727-3595 Fax: 631-727-3611

Walter Mahaffee
Research Plant Pathologist
3420 NW Orchard Ave
Corvallis, OR 97330
Phone: 541-738-4036 Fax: 541-738-4025
Email: mahaffew@science.oregonstate.edu

Doug Gubler
Department of Plant Pathology
One Shields Ave.
University of California
Davis, CA 95616
Tele: 530-752-0304 Fax: 530-752-5674
Email: wdgubler@ucdavis.edu

4. Type of grant:
Monitoring, forecasting, and economic thresholds

5. Project location(s):
Project Location: Tioga County, South Central NY
Initial Model Test Data: Long Island, NY

6. Abstract:
Powdery mildew is a serious disease of pumpkin throughout the Northeastern United States. Control of pumpkin powdery mildew is currently achieved through the use of a calendar-based application of fungicides. Three non-pumpkin weather-based fungicide scheduling programs for powdery mildew were evaluated to determine their usefulness in the control of cucurbit

powdery mildew using fewer appropriately timed fungicide applications. None of the weather-based fungicide scheduling programs provided a benefit in fungicide scheduling compared to the calendar-based fungicide application scheduling when evaluated with historical weather and disease initiation data. The weather-based fungicide scheduling programs function primarily by determining conditions that are not suitable for the proliferation of powdery mildew. New York State experiences favorable conditions for the growth of powdery mildew throughout the cucurbit growing season in most years, therefore reducing the utility of the weather-based fungicide scheduling programs in this region.

7. Background and justification:

New York is currently the third largest producer of pumpkins in the nation with an estimated farm-gate value of $23.9 million in 2002(1). An economically important disease of pumpkin production in New York, and throughout the Northeast, is powdery mildew; currently reported as the obligate fungal pathogen *Sphaerotheca fuliginea* (2). Control practices for powdery mildew on pumpkin involve the use of powdery mildew resistant varieties of pumpkin and by the repeated calendar-based application of fungicides (3).

In recent years, there have been efforts to use remote weather sensing equipment and computers to schedule fungicide treatments by predicting pathogen development for various diseases and crops. Weather-based fungicide scheduling programs for powdery mildew have developed primarily for wine grape crops due to a very low acceptable tolerance for grape powdery mildew, *Uncinula necator*, in wine (4). These weather-based fungicide scheduling programs show the potential for reducing overall fungicide applications in years when environmental conditions for powdery mildew development are low. Currently, grape powdery mildew weather-based fungicide scheduling programs have been developed and implemented in Australia and New Zealand (5), Germany (6), Italy (7), California (8), and New York (Gadoury, as tested by Pscheidt (9, 10)).

The intent of this grant was to evaluate the performance of existing weather-based fungicide scheduling programs for control of powdery mildew in pumpkin plantations in the central region of New York State.

8. Objectives:

1. Identify three fungicide scheduling programs that would be suitable for field trials.
2. Evaluate the usefulness of pre-existing non-pumpkin powdery mildew fungicide scheduling programs for the control of pumpkin powdery mildew.
3. Project Evaluation and Reporting

9. Procedures:

Fungicide Scheduling Programs

Existing weather-based fungicide scheduling programs for powdery mildew were identified for evaluation (Objective 1). Additional fungicide scheduling programs do exist, but obtaining specifics on their function was not possible at this time.

UC Davis Grape Powdery Mildew Risk Index

Developed for powdery mildew control in grape for the central inner-valley and coastal regions of California and applied to various regions around the world. This program uses temperature as the driving environmental parameter to predict a risk assessment score (0-100). The risk assessment score is then categorized into three reproduction rate groupings: 0 – 30 slow, 40 – 50 normal, and 60 – 100 high rates of reproduction. Spray interval rates are lengthened or shortened based on the forecasted rates of pathogen growth (Table 1).

Table 1. Treatment timing guidelines based on risk index and spray material. Reprinted from Disease Model Data Base: Powdery Mildew of Grape (http://www.ipm.ucdavis.edu/DISEASE/DATABASE/grapepowderymildew.html)

Powdery Mildew Risk Index	Spray Material	Spray Interval
0 to 30	Sulfur dust Micronized sulfur DMI Fungicides*	14 Days ** 18 Days ** 21 Days**
40 to 50	Sulfur dust Micronized sulfur DMI Fungicides*	10 Days 14 Days 17 Days
60 to 100	Sulfur dust Micronized sulfur DMI Fungicides*	7 Days 10 Days 14 Days

* Demethylation inhibitors such as Bayleton, Rally, Rubigan
** Or label maximum

HOPS Risk Index – (Help Our Plants Survive)

Developed by the USDA-ARS for powdery mildew control on hop plantations in cool climate regions of Idaho, Oregon, and Washington. This program is very similar to the UC Davis Grape Powdery Mildew Risk Index with the exception of the addition of a rain fall parameter. Maximum and minimum temperatures, and rain fall are used to predict a risk assessment score (0-100). The risk assessment score is then categorized into three reproduction rate groupings: 0 – 30 slow, 40 – 50 normal, and 60 – 100 high rates of reproduction. Spray interval rates are lengthened or shortened based on the forecasted rates of pathogen growth (Table 2), which is simply an updated version of the UC Davis Grape Powdery Mildew Risk Index treatment timing guidelines.

Table 2. Example of treatment timing guidelines based on risk index and spray material. Reprinted from "Information package on using HOPS: an infection risk forecaster for hops powdery mildew" (10)

Infection Risk Index	Spray Material	Spray Interval
0 to 30	Biologicals Copper, sulfur Bicarbonates DMI fungicides* Oils Stobulorins	See label 14 days ** 10 days ** 18 days ** 14 days ** 14 days **
40 to 50	Biologicals Copper, sulfur Bicarbonates DMI fungicides* Oils Stobulorins	See label 10 days 8-9 days 14 days 10 days 10 days
60 to 100	Biologicals Copper, sulfur Bicarbonates DMI fungicides* Oils Stobulorins	See label 7 days 7 days 10 days 7 days 7 days

Legal uses of many pesticides are consistently changing, therefore always obtain and read current label prior to using a product.

* Demethylation inhibitors such as Folicur, Rally
** Or label maximum

UC Davis Tomato Powdery Mildew Risk Index

Developed for powdery mildew control in Tomato for the regions of Southern California and has not been applied to many forecasting systems. This program is the most difficult to implement due to its requirement for hourly averages of temperature, relative humidity, and leaf wetness. A complex regression was used to develop a list of daily "linear discriminant function" (Conditions) output, which is then used in a predefined set of decision rules for fungicide application timing (Table 3.)

Table 3. Decision rules, expected disease severity, and recommended actions based on evaluation of a six-day period of daily conditions. Reprinted from Disease Model Data Base: Powdery Mildew of Tomato (http://www.ipm.ucdavis.edu/DISEASE/DATABASE/tomatopowderymildew.html)

Conditions*	Expected Disease Severity	Spray Recommendation	Next Evaluation of a six-day period
All N days	None	Don't Spray	6 days later
All C days	Severe	Spray	16 days after the last spray
All M days	Moderate	Don't Spray	3 days later
All M & N days, no 2 N days are consecutive	None to Moderate	Don't Spray	3 days later
At least one series of at least 2 consecutive N days	None to Moderate	Don't Spray	6 days after last N period
At least 3 C days, no 2 N days are consecutive	Moderate to Severe	Spray	16 days after the last spray
Less than 3 C days, no 2 N days are consecutive	Moderate	Don't Spray	1 day later

* N=Nonconductive, M=Moderate, C=Conductive

Historical Data Program Evaluation

Historical disease detection and environmental weather data was provided by Margaret Tuttle McGrath from experiments previously conducted in Riverhead, NY. Of the data sets available, three of the most complete data sets were chosen (1998, 2000, and 2001).

The fungicide scheduling programs were evaluated using the historical data with the following assumptions:

1. Dates when powdery mildew was first observed in a field were used as the trigger to initiate the fungicide scheduling programs regardless of their published initiation criteria. The dates when powdery mildew was first observed in the field were 15 August, 28 July, and 4 August, for 1998, 2000, and 2001 respectively.
2. The first fungicide applications were assumed to also occur on the dates when powdery mildew was first observed in the field.
3. Fifteen minute weather data was not available, therefore hourly average high and low temperature data used with the UC Davis Tomato Powdery Mildew Risk Index were estimated using recorded hourly temperature data.

4. An industry standard spray rotation between Stobulorins and DMI fungicide were used as the hypothetical fungicides used in the historical data program evaluation.
5. Fungicide scheduling programs were compared to a typical calendar based fungicide program for moderate powdery mildew pressure (Strobulorin 10 day interval, DMI 14 day interval).
6. No fungicide sprays were theoretically applied beyond 15 October in any historical growing year.

Field Validation of Fungicide Scheduling Programs

A field validation was not conducted on the fungicide scheduling programs based of their performance evaluation using historical data. Procedures of a field validation have been excluded from this report.

10. Results and discussion:

Fungicide Scheduling Program Risk Index Response Results

Powdery mildew was detected in the field on 15 August, 28 July, and 5 August in 1998, 2000, and 2001 respectively. All fungicide scheduling programs were initiated on the date when powdery mildew was detected in the field.

During the 1998 historical data, the UC Davis Grape Powdery Mildew Risk Index quickly climbed to the severe index category and remained at the sever category until 6 October (Figure 1). The UC Davis Grape Powdery Mildew Risk Index then steadily declined to a no measurable risk index (Index = 0) on 11 October, where it remained for the conclusion of the evaluation. The HOPS Risk Index accumulated risk index points much in the same way as the UC Davis Grape Powdery Mildew Risk Index, with the exception of noticeable dips in risk index points during significant rain fall events (17-18 August, 7-8 September, 22 September, 27 September, and 7-10 October). The severe index category was reached 22 August and remained within the severe index category until 15 October. The HOPS Risk Index quickly returned to the severe index category on 16 October. The HOPS Risk Index remained in the severe category again until 28 October, at which time the program proceeded to decline. The UC Davis Tomato Powdery Mildew Risk Index responded much differently than the previous two programs. The index initially climbed to a moderate risk index category (Index = 1) and remained moderate for the duration of the season with only occasional decreases to the no risk category (Index = 0) on 23 September, 30 September – 1 October, 13-14 October, and 25 October. The UC Davis Tomato Powdery Mildew Risk Index indicated a risk index of severe for one day on 30 October.

In 2000, the UC Davis Grape Powdery Mildew Risk Index again quickly climbed to the severe index category and remained severe until 28 September (Figure 2). The risk index steadily dropped to a low risk index by 1 October. The risk index indicated one more moderate risk event between 13 October and 21 October. The HOPS Risk Index responded much the same as in 1998. The risk index began to increase on the initiation of the program and a prolonged rainfall between 28 July to 3 August reduced the risk index to no risk (Index = 0). The program then proceeded to increase the risk index quickly to severe where it remained for the duration of the year 2000 dataset. Again, the UC Davis Tomato Powdery Mildew Risk Index responded much differently than the previous two programs. The risk index quickly increased to a moderate risk (Index = 1) and basically remained moderate for the duration of the evaluation, with the exception of occasional changes to either no risk or high risk.

The 2001 historical data was lacking environmental data from 22 August to 15 September, but was used in the evaluation due to the availability of no other suitable data sets. Again, the UC Davis Grape Powdery Mildew Risk Index quickly climbed to the severe index category and remained at the sever category (excluding the missing data) until 29 September (Figure 3). At that point the program began to fluctuate between low to severe risk with fluctuations in daily temperature until the risk index drop to no risk on 20 October. The HOPS Risk Index responded much as it had in the previous years. The risk index rapidly increased, but was lowered by a rain event on 10 August. The program then proceeded rapidly to a severe risk index and remained there for the remainder of the evaluation. The UC Davis Tomato Powdery Mildew Risk Index again increased to a moderate risk and effectively remained at a moderate risk for the duration of the evaluation.

Fungicide Scheduling Program Spray Frequency Results

Hypothetical spray scheduling was estimated for a moderate disease pressure calendar based fungicide application program and compared to fungicide scheduling program spray recommendations (Figure 4).

In 1998, six hypothetical calendar based sprays were applied. This was the treatment with the fewest sprays excluding the UC Davis Tomato Powdery Mildew Risk Index, which did not recommend a single fungicide application. Both the UC Davis Grape Powdery Mildew Risk Index and the HOPS Risk Index recommended spray intervals that equated into seven and eight fungicide applications respectively. The UC Davis Grape Powdery Mildew Risk Index did extend one recommended spray interval from the minimum labeled interval between 11 October and the end of the evaluation period. The extension in recommended spray interval did save the use of one fungicide application for the UC Davis Grape Powdery Mildew Risk Index.

In 2000, seven hypothetical calendar based sprays were applied. This was the treatment with the fewest sprays excluding the UC Davis Tomato Powdery Mildew Risk Index, which never recommended a single fungicide application. Both the UC Davis Grape Powdery Mildew Risk Index and the HOPS Risk Index recommended spray intervals that equated into nine fungicide applications each. Very short extensions in the minimum labeled fungicide application interval were recorded for both the UC Davis Grape Powdery Mildew Risk Index and the HOPS Risk Index, but these extensions did little to reduce the overall number of fungicide applications.

In 2001, six hypothetical calendar based sprays were applied. This was the treatment with the fewest sprays excluding the UC Davis Tomato Powdery Mildew Risk Index, which never recommended a single fungicide application. Both the UC Davis Grape Powdery Mildew Risk Index and the HOPS Risk Index recommended spray intervals that equated into nine and eight fungicide applications respectively. Again, very short extensions in the minimum labeled fungicide application interval were recorded for both the UC Davis Grape Powdery Mildew Risk Index and the HOPS Risk Index.

Conclusion

It would appear that none of the fungicide scheduling programs evaluated with historical data were successful in reducing the number of fungicide applications during the three years of historical data. Both the UC Davis Grape Powdery Mildew Risk Index and the HOPS Risk Index reduce the risk index for events that inhibit powdery mildew development. These inhibiting conditions are not evident in historical weather data with the exception of a minor reduction in risk index with the HOPS Risk Index due to rain events. Optimum conditions for powdery mildew development occur throughout the period from when powdery mildew is detected within the field to just before pumpkin harvest when fungicides are typically not applied. The UC Davis Tomato Powdery Mildew Risk Index did not function properly for this region, or for the historical data's environmental parameters.

Testing other weather-based fungicide scheduling programs would probably result in the same result as most programs are based on conditions that inhibit powdery mildew development (very high or very low temperatures, or significant rain fall). Additionally, most fungicide scheduling programs were designed for crops that have a very low tolerance for powdery mildew infection. An economic tolerance threshold for powdery mildew in pumpkin has not been determined, but could then be used to “desensitize” an existing fungicide scheduling program. A “desensitized” fungicide scheduling program could then reduce the overall number of recommended fungicide applications during times when conditions for powdery mildew development are less than optimal.

It is suggested that the fungicide scheduling programs be evaluated for use in greenhouse and high tunnel production of cucurbits. Conditions inhibiting the development of powdery mildew occur frequently in those environments, even in the Northeastern United States.

Timely field scouting and calendar based fungicide applications would appear to be the best recommendation for the control of powdery mildew in pumpkin. The use of weather-based fungicide scheduling programs did not improve upon the current New York Integrated Pest Management recommendations and did not reduce the numbers of hypothetical fungicide applications in this program evaluation.

11. References:

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Figure 1: Fungicide Scheduling Program Evaluation with Historic Data – 1998: Powdery mildew was discovered in field on 15 August (Vertical Black Bar) and was used to initiate all scheduling programs.

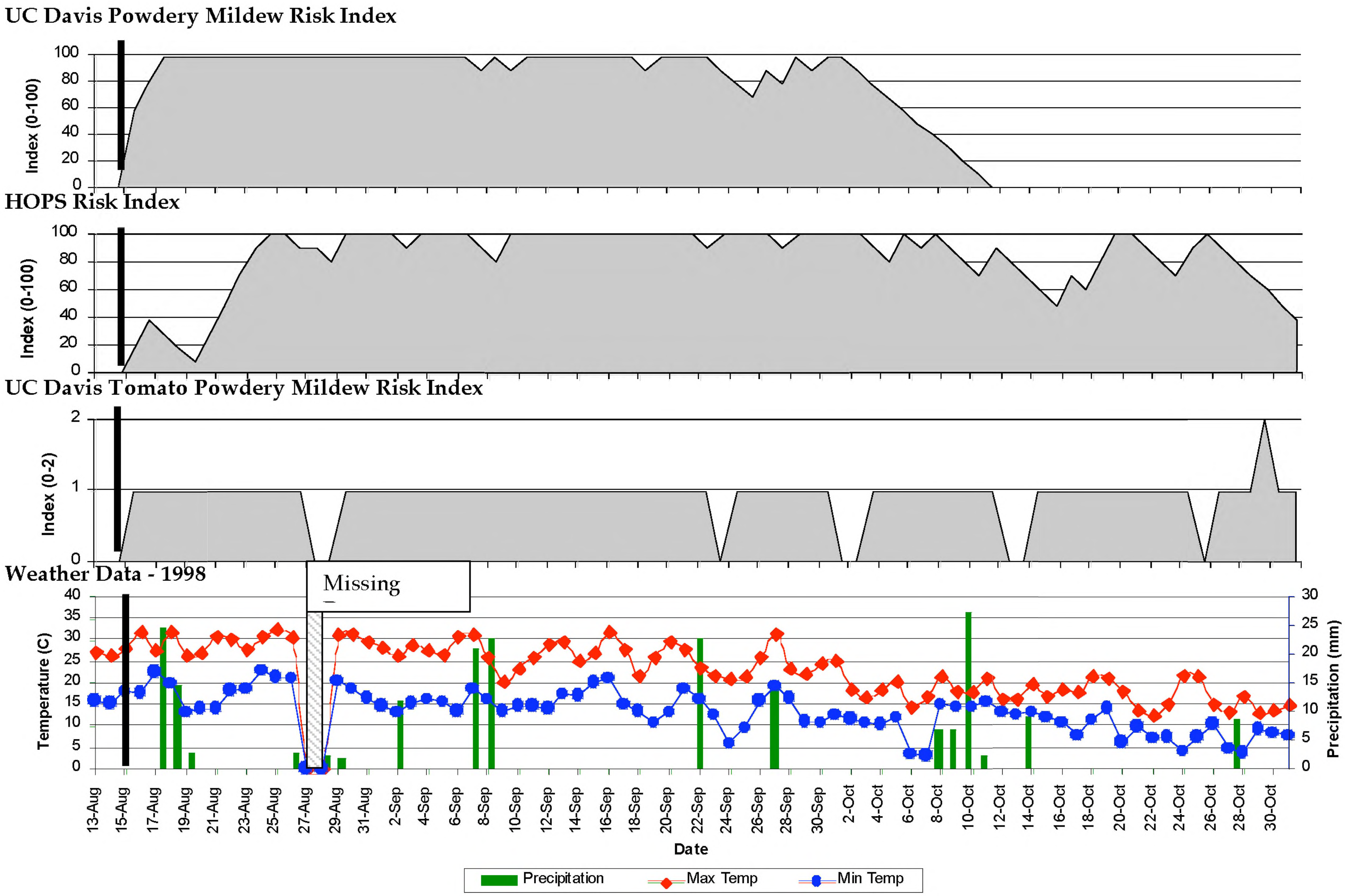
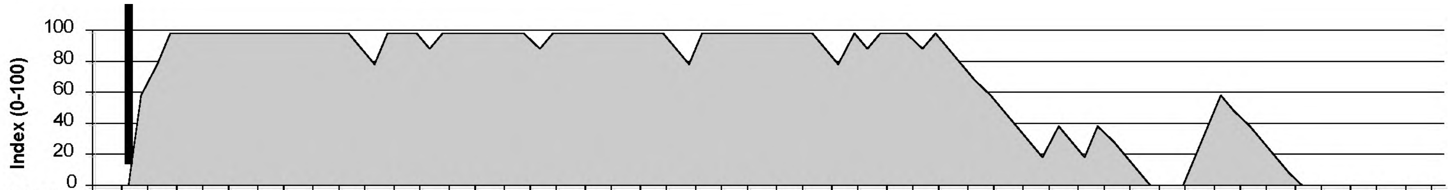
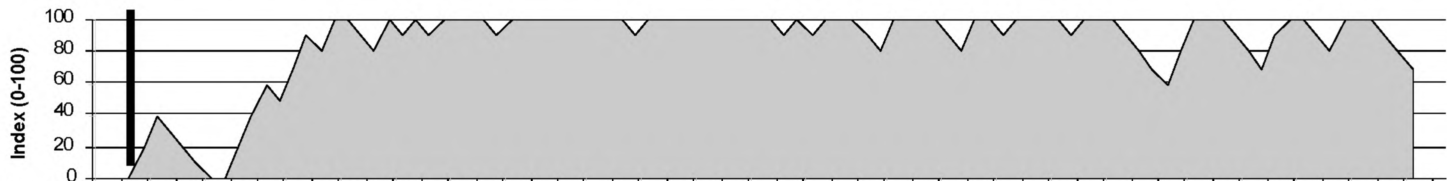


Figure 2: Fungicide Scheduling Program Evaluation with Historic Data – 2000: Powdery mildew was discovered in field on 28 July (Vertical Black Bar) and was used to initiate all scheduling programs.

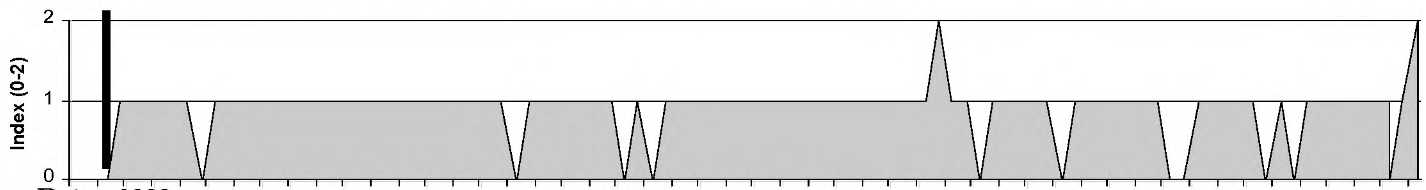
UC Davis Powdery Mildew Risk Index



HOPS Risk Index



UC Davis Tomato Powdery Mildew Risk Index



Weather Data - 2000

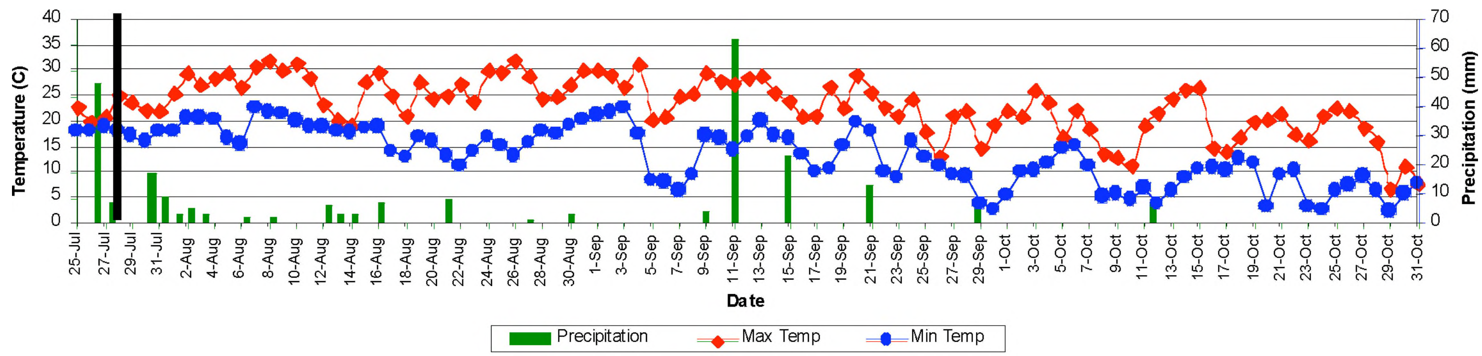


Figure 3: Fungicide Scheduling Program Evaluation with Historic Data – 2001: Powdery mildew was discovered in field on 4 August (Vertical Black Bar) and was used to initiate all scheduling programs.

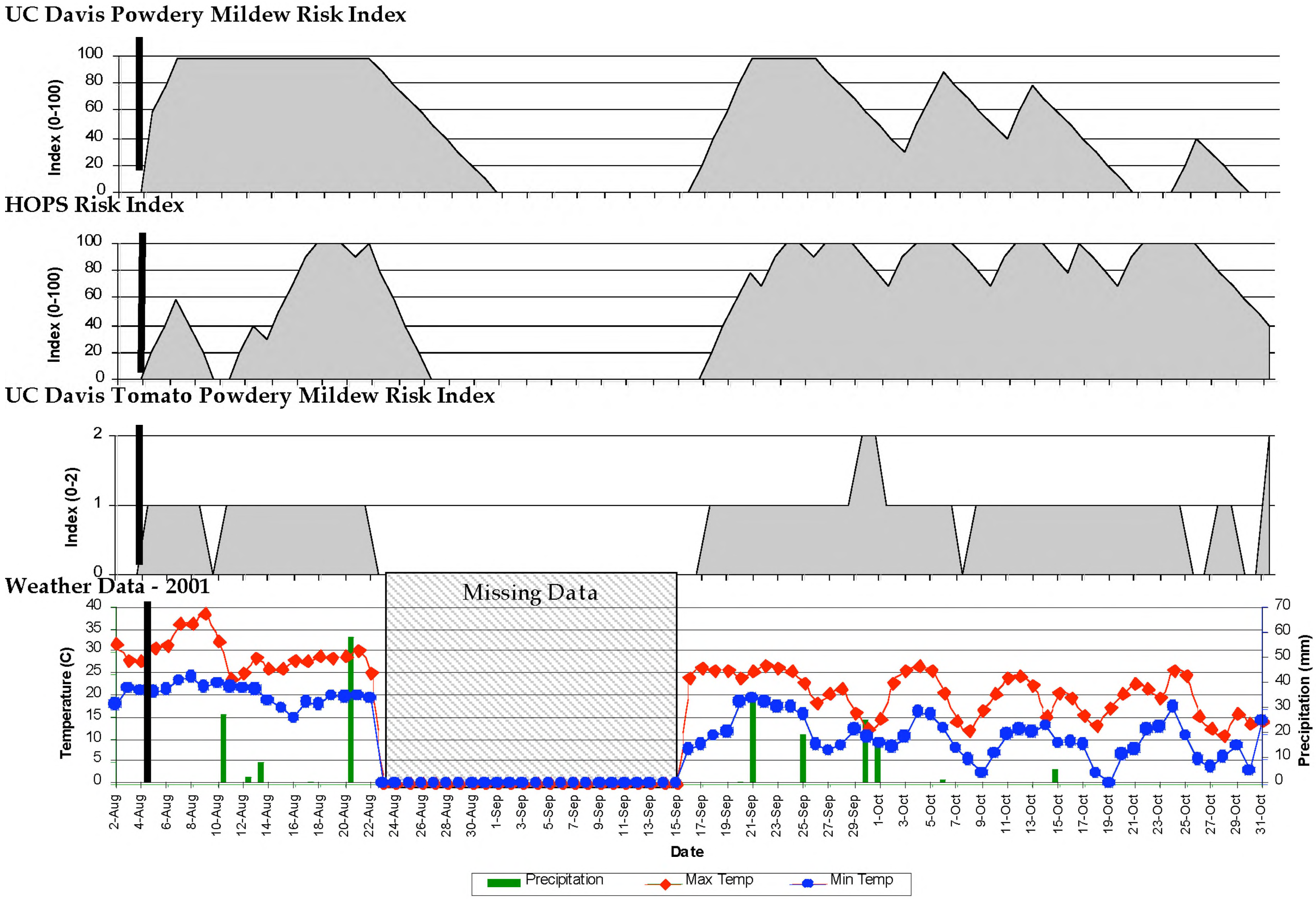


Figure 4: Hypothetical Fungicide Applications Based on Historical Data – 1998, 2000, and 2001