Cooperative Extension | University of California | Santa Barbara/Ventura Counties

UCCE & DPR Sponsored

California Department of Pesticide Regulation

Lompoc
Row Crop Pest Management
Project

No. 6

Late Blight of Celery (*Septoria apiicola*): Timing Fungicides Based On Its Biology As Predicted By In-Field Weather Stations

University of California Cooperative Extension

624 W. Foster Road, Suite A
Santa Maria, CA 93455

IPM Information Series

June, 1997

Late Blight of Celery (*Septoria Apiicola*): Timing Fungicides Based On Its Biology As Predicted By In-Field Weather Stations

By Phil A. Phillips

Background

In addition to insect pest damage, celery is extremely susceptible to attack from *Septoria apiicola*, the causal organism of Septoria leaf spot or late blight, during extended periods of leaf wetness (Berger, 1990), as well as other disease causing pathogens. As a result, standard management recommendations include the prophylactic application of fungicides at weekly, biweekly or occasionally less frequent intervals from transplanting until harvest (CVPQ 1987; OMAF 1988; Skylakakis 1983). Concerns for the development of resistance by *S. apiicola* to currently used fungicides and for the environmental impact those fungicides have spurred interest in development of improved management practices (Paulus et al. 1979; Mathieru & Kushalappa 1993). Because of the importance of meteorological conditions on disease development (Jones, 1986), recent research has focused on understanding disease epidemiology and the development of disease forecasting models. These disease forecasting models are based on the key parameters of leaf wetness duration and temperature and forecast critical periods for disease development (Madden & Ellis 1988; Mudita & Kushalappa 1991; Sheridan 1968). Fungicides are then applied only when disease severity values reach threshold levels. Where disease forecasting models for Septoria blight have been field tested, significant reductions (25-50%) in fungicide applications have been achieved with no economic reduction in crop yield or quality (Mudita & Kushalappa 1991).

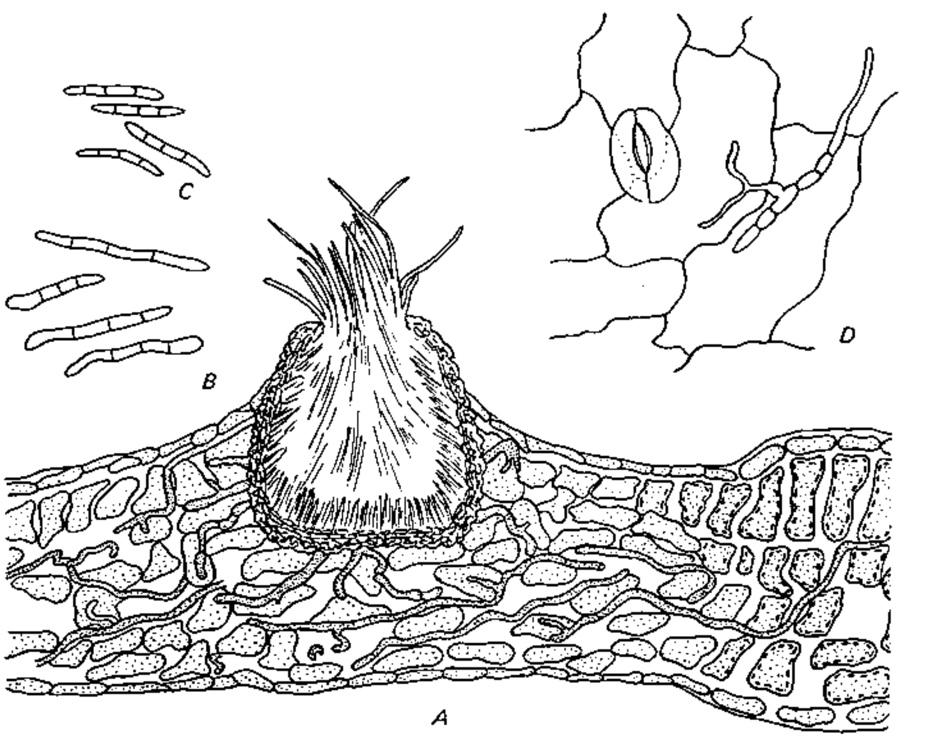
Septoria apiicola can attack any part of the plant above ground. As outer leaves and stalks turn dark and wither, the entire field may look scorched.

The fungus is seed-borne. It also overwinters on debris from a previous crop. It may get started in the seedbed where it forms small, circular, water-soaked spots on the leaves about one-sixteenth inch in diameter. In 10 or 20 days, the spots turn nearly black and become filled with many minute black dots, the fruiting bodies (pycnidia) of the fungus (Figure 1). Spores are formed in these closed, black, pear-shaped cups partly embedded in the plant. They are exuded during wet weather as gelatinous, snakelike tendrils, and require spattering raindrops rather than air currents for quick spread.

When celery is wet with dew, equipment or the clothes of workers can spread the fungus down the row. K. H. Lin, at the New York State College of Agriculture, found that the number of spores in a single pycnidium - a structure no larger than the dot over this i - varied between 1,449 and 5,493, with a mean for nine pycnidia of 3,675. More than 2,000 spots (lesions) can exist on untreated plants, with an average of 56 pycnidia per spot; potentially, therefore, half a billion spores can be produced on one plant.

Germinating Septoria spores can penetrate directly through the epidermis as well as through stomata and as readily on the upper surface of leaves as on

Figure 1. Celery-late blight organism. A, diagrammatic sketch showing cross section of pycnidium and mycelium in celery leaf; B, pycnospores of a small-spot form; C, pycnospores of a large-spot form; D, germinating pycnospore adjacent to a stoma.



the lower surface, although there are only about one-third as many stomata on the upper surface.

In polycyclic diseases (those that pass through multiple disease cycles during a given cropping period), such as Septoria late blight in celery, the initial inoculum, although important, is minor when compared to the existing rate parameters of temperature and leaf wetness duration when predicting final disease levels (Fry 1982). In other words, the need for disease suppressive treatments will depend more on the occurrence of optimum temperature and leaf wetness conditions than on whether the initial inoculum load in the field was heavy or light. However, if a celery field has high inoculum levels at transplanting, as in the case of infected plants coming from the nursery, there is no room for error in the choice and timing of disease management practices as compared to a field with low inoculum levels.

Current Situation

Over the last several years Campbell Soup's Research Department has successfully used a Septoria forecasting model (patterned after the "Tom-Cast" model for Alternaria blight on tomato) with its celery growers who have saved one or more fungicide applications with each crop (Bob Curtis, Campbell's Research Dept., pers. comm.). Probably more important than saving the costs of fungicide applications which weren't needed is the increased accuracy in timing fungicide applications when they are needed. Since the model links the timing of fungicide applications with the potential for disease development as it is measured on site in the celery field, fungicides can be applied more on an as needed basis than on a purely calendar or best guess basis.

There are a number of manufacturers offering various weather measuring instrumentation and software packages which can be used to forecast disease development and time fungicide applications (see accompanying annotated list).

At the low tech end, a simple logger with a temperature and a leaf wetness probe along with some hand calculations will suffice.

The Model - How It Works

The Septoria model is really very simple. It operates under the premise that within given temperature ranges there are specific requirements (thresholds) for consecutive hours of leaf wetness before spore development and germination can take place. This is analogous to degree-day models for insects which depend on a known temperature threshold for development for the organism in question (see Information Series #1). Each day that temperature and leaf wetness conditions exceed the lower thresholds, a certain number of DSV's (disease severity values) are contributed to the progress of the disease. A conservative accumulation of 20 DSV's is currently used to determine the timing for fungicide applications. It is likely that with additional research, this threshold can be relaxed to 25 or 30 DSV's accumulated before fungicide application is warranted.

Table #1 is the basic model. On the left side of the table are the temperature ranges within which different disease severity values are assigned depending upon the hours of leaf wetness occurring each day. The body of the table consists of various periods of leaf wetness. Thus by calculating the average temperature (the table uses Centigrade) during the period of leaf wetness, one can read across the table from the calculated average temperature to the appropriate period of measured leaf wetness and then follow up the table to obtain the corresponding DSV located at the top of the table.

An example is presented in Figure #2. Here, the leaf wetness probe being used has a

Table 1
Disease severity values (DSV's) as a function of leaf wetness period and average air temperature during the wetness period.

	Leaf-wetting time (hr) required to produce daily disease severity values of:					
Mean Temp (C)	DS V's					
	0	1	2	3	4	
13-17	0-6	7-15	16-20	21+		WET HOURS
18-20	0-3	4-8	9-15	16-22	23+	
21-25	0-2	3-5	6-12	13-20	21+	
26-29	0-3	4-8	9-15	16-22	23+	

Madden, L., S.P. Pennypacker, and A.A. MacNab. Phytopathology 68:1354-1358.

Figure #2 - Example				
Month	Day	Hour	Temp.	Leaf Wetness
6	21	1230	22.5	7
6	21	1330	21.5	8
6	21	1430	21.0	7
6	21	1530	19.0	8
6	21	1630	17.5	8
6	21	1730	15.5	50
6	21	1830	14.0	163
6	21	1930	13.0	168
6	21	2030	12.5	171
6	21	2130	12.5	172
6	21	2230	13.0	175
6	21	2330	14.0	180
6	22	30	14.5	181
6	22	130	14.5	183
6	22	230	14.0	184
6	22	330	14.0	185
6	22	430	14.0	187
6	22	530	14.5	191
6	22	630	15.0	174
6	22	730	16.5	67
6	22	830	19.0	13
6	22	930	20.0	7
6	22	1030	21.5	7
6	22	1130	22.0	8

LEAF WETNESS HOURS = 16 (SHADED AREA)

MEAN TEMPERATURE DURING WET PERIOD = 14.4 °C

2 DSV'S ACCUMULATED THIS PERIOD BASED ON TABLE 1.

Figure #3 - Example				
Month	Day	Hour	Temp.	Leaf Wetness
6	19	1130	19.0	201
6	19	1230	19.0	200
6	19	1330	19.0	65
6	19	1430	18.5	8
6	19	1530	18.5	7
6	19	1630	18.0	8
6	19	1730	16.0	11
6	19	1830	14.0	122
6	19	1930	13.5	169
6	19	2030	12.5	170
6	19	2130	12.5	172
6	19	2230	11.5	173
6	19	2330	11.5	171
6	20	30	11.5	168
6	20	130	10.5	165
6	20	230	10.0	162
6	20	330	9.5	159
6	20	430	11.0	160
6	20	530	15.5	167
6	20	630	21.5	96
6	20	730	25.0	9
6	20	830	20.0	8
6	20	930	21.0	7
6	20	1030	22.5	7

LEAF WETNESS HOURS = 14 (SHADED AREA)

MEAN TEMPERATURE DURING WET PERIOD = 12.9 °C

0 DSV'S ACCUMULATED THIS PERIOD TEMP. BELOW 13 °C

threshold level of 10 for wetness. Levels below 10 are considered dry, while 10 and above are considered wet. Thus, on 6/21 the hours of leaf wetness were from 1730 (5:30 pm) until 0830 (am) the following day for a total of 16 hours. For calculating leaf wetness hours one "day" usually runs from noon-to-noon (noon one day to noon the following day), since wetness often occurs over night. The average temperature for this wetness period was 16 degrees C, well above the lower critical threshold of 13 °C for Septoria development. Using Table #1, a period of 16 hours of leaf wetness at 16 °C average temperature during this period contributes "2" DSV's to the "life cycle" of the pathogen.

Figure # 3 shows a situation where, despite a lengthy leaf wetness period of 14 hours, no DSV's were contributed to the pathogen "cycle" because the average temperature was below the 13 °C threshold.

Table # 2 gives an example of how the model is actually used. Here, the celery grower has a simple data logger located in his celery field. He has a temperature probe and a leaf wetness probe attached to the logger and placed within the celery canopy. Monitoring began at transplanting on 3/24/95, but temperatures were too cool to generate DSV's until 4/4/95. Most other dates with temperatures below 13 °C during the leaf wetness period are also left off the table. Those dates which contributed DSV's to the pathogen's cycle are shown in this table. A treatment threshold level of 20 DSV's wasn't reached until 5/3/95, with the fungicide being applied early in the morning on 5/7/95. Thus the accumulation starts again from this point until 5/31/95, when an accumulation of 19 was reached and a decision to

TABLE 2
CELERY, Oxnard, 1995
DATAPOD AVERAGES

DATE Start 3-24-95	HOURS		AVERAGE TEMP	DSV	ACCUM. DSV's
4-4	22	(Irrigating)	15.4	3	3
4-5	20		14.3	2	5
4-12	11		13.1	1	6
4-27	19	(Irrigating)	15.6	2	8
4-28	18	"	14.2	2	10
4-29	22	"	16.4	3	13
4-30	22	"	16.0	3	16
5-1	18	"	15.9	2	18
5-3	18		14.1	2	20
5-7	15	Treated early am 5-8-95	13.0	1	21
5-14	21		13.1	2	2
5-19	18		13.6	2	4
5-20	18		13.3	2	6
5-22	10		13.5	1	7
5-23	16		13.7	2	9
5-24	10		14.0	1	10
5-25	18		14.2	2	12
5-26	5		14.1	0	12
5-27	3		14.3	0	12
5-28	24		14.1	3	15
5-29	11		14.0	1	16
5-30	20		14.2	2	18
5-31	14		14.4	1	19
6-1	6	Treated early a.m.	14.3	0	19
6-2	5	Treated early a.m.	14.5	0	0

Comments: No DSV's 3/24 to 4/3/95
Temperature Sensor out 5/22 to 5/30/95

treat again was made. This process continued throughout the crop cycle, retreating appoximately every 20 DSV's.

Fungicide application timing decisions must obviously be based on more than just what this model predicts. Considerations of insecticide timing, irrigation scheduling and predicted harvest date all play a role in the final decision as to when to apply a fungicide.

Table 3 gives a few sources for microclimatic measuring weather stations and probes.

Table #3
Some Weatherstation Sources

Model Name	Manufacturer	Also available from	Sensors	Telemetry available
Weather-One Pkgd Station Quick-One Portable GroWeather Station EasyLogger 900 Series Datapod Series	Dataloggers, Division of OmniData International, Inc. PO Box 361 Logan UT 84323-0361 (801) 753-9311 (801) 753-8177 fax		Variety	On some models
Compact Series Dat D.	METOS Instruments, Inc. 408 N. 1st Street P.O. Box 583 Yakima, WA 98907-0583 (509) 453-4851 (509) 452-6571 pess1@computerhaus.at email	Gempler's P.O. Box 270 211 Blue Mounds Road Mt. Horeb, WI 53572 (800) 272-7672 (800) 551-1128 Fax 71134.3153@compuserve.com email	Variety	Radio, telephone
MetDatal CR 10X Datalogger CR 500 Datalogger	Campbell Scientific, Inc. 815 W. 1800 N. Logan, UT 84321-1784 (801) 753-2342 (801) 750-9540 fax www.campbellsci.com info@csius.com email	Weather Network 568 Manzanita Ave., Suite 1 Chico, California (916) 893-0308 (916) 893-4517 fax ----- Intermountain Environmental, Inc. 601 W. 1700 S., Suite B Logan, UT 84321 (800) 948-6236 (801) 755-0794 fax www.inmtn.com info@inmtn.com email	Variety	Radio, telephone
AgroExpert	Adcon Telemetry P.O. Box 7908 Santa Rosa, CA 95407-0908 (800) 352-5309 (707) 578-2390 fax adcon.com	Western Farm Service California Valley North Division 509 W. Weber Ave., Suite 201 Stockton, CA 95203 (209) 547-2637 (209) 464-4652 fax	Variety	Radio

Works Cited

Berger, R.D. 1970. Epiphytology of celery late blight. Florida State Hort. Soc. Proc. 83:208-212.

CPVQ (Conseil des productions vegetales du Quebec). 1987. Legumes, Protection AGDEX 250-605. Ministere de l'Agriculture, del Pecheries et de l'Alimentation du Quebec. 112 pp.

Fry, W. E. 1982. Principles of Plant Disease Management. Academic Press, New York.

Jones, A.L. 1986. Role of wet periods in predicting foliar diseases. Pages 87-100 IN: Plant Disease Epidemiology, Population Dynamics and Management. K.J. Leonard and W.E. Fry, eds. MacMillan Publishing Co., New York.

Madden, L., S.P. Pennypacker, and A.A. MacNab. 1978. FAST, a forecast systems for *Alternaria solani* on tomato. Phytopathology 68:1354-1358.

Madden, L.V. and M.A. Ellis. 1988. How to develop plant disease forecasters. Pages 191-207 in: Experimental Techniques in Plant Disease Epidemiology. J. Kranz and J. Rotem, eds. Springer-Verlag, New York.

Mathieu, D. and A.C. Kushalappa. 1991. Effects of temperature and leaf wetness duration on the infection of celery by *Septoria apiicola*. Phytophathology 83(10):1036-1040.

Mudita, W. and A. C. Kushalappa. 1991. Effect of media and temperature on sporulation of *Septoria apiicola*, and of inoculum density on Septoria blight severity in celery. Phytoprotection 72:97-103.

Ontario Ministry of Agriculture and Food. 1988. Vegetable Production Recommendations. OMAF Publ. 363. 78 pp.

Paulus, A., J. Nelson, and H. Otto. 1979. Combination versus single fungicides for control of Septoria leaf spot in celery. Cal. Ag. 33:15.

Sheridan, J.E. 1968. Conditions for germination of pycnidiospores of *Septoria apiicola*. Speg. N.A. J. Bot. 6:315-322.

Skylakakis, G. 1983. Theory and strategy of chemical control. Ann. Rev. Phytopathol. 21:117-135.