Assessment of Peanut Leaf Spot Disease Control Guidelines Using Climatological Data

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ABSTRACT

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Early leaf spot, caused by *Cercospora arachidicola,* and late leaf spot, caused by *Cercosporidium personatum,* can be controlled by foliar fungicides. Extension recommendations in South Carolina suggest planting peanuts between 15 April and 15 May. The recommended starting date to initiate 10- to 14-day fungicide spray schedules to control leaf spot is 15 June. The 1980–1990 climatological data for Sumter, Florence, and Blackville, South Carolina, were used to simulate calendar spray schedules and a method for spray timing developed at Auburn University (AUPNUT) that used observed and forecast rainfall. This simulation showed that adoption of AUPNUT scheduling in South Carolina could result in less foliar fungicide usage than the 10- and 14-day calendar-based spray schedules. The study showed: (i) the number of AUPNUT sprays depended on location in the state; (ii) the AUPNUT schedule added one application prior to 15 June on early-planted fields but averaged less than one additional spray per year for later plantings when compared to a 14-day calendar-based schedule that started on 15 June; (iii) at least one spray per year can be saved regardless of planting time, and up to five sprays can be saved depending on the distribution of days with rain; and (iv) a simulation using historical weather data can demonstrate potential savings associated with adoption of new application schedules.

The long-range savings potential of a chemical spray schedule cannot be easily extrapolated from limited field trials. When a schedule depends on weather, however, historical weather data can be used to simulate applications over many years. Estimates of potential cost savings can then be based on an analysis of the simulated spray applications.

Leaf spot diseases can devastate a peanut (*Arachis hypogaea L.*) crop. Yield reductions of 1,100 kg/ha or more are common in severely infected Georgia and Florida fields (8). Early leaf spot, caused by *Cercospora arachidicola* Hori, and late leaf spot, caused by *Cercosporidium personatum* (Berk. & Curt.) Deighton, can be controlled by a foliar fungicide applied at 10- to 14-day intervals throughout the growing season. Since the fungicide must be present prior to spore germination in order to inhibit infection, timing of each application is a critical part of a control program. The first spray is applied before disease is observed in the field or at a disease threshold of two lesions per plant (1). Regular applications after the initial spray can keep the disease in check.

Since both temperature and leaf wetness are necessary for spore germination and fungal survival, weather is the major factor in disease development and, consequently, in its control (9,15). Weather-based guidelines for controlling early leaf spot were first developed by Jensen and Boyle (10), who used temperature and relative humidity to describe conditions favorable for successful infection. The use of temperature and humidity has been tested extensively, and these measurements are now incorporated into computer programs (3,13) and into commercial leaf spot disease advisory equipment (5,14). A somewhat simpler scheme (AUPNUT), developed by researchers at Auburn University (1), requires only rainfall and a rainfall forecast as indicators of leaf wetness and the development of leaf spot (2,6,7).

Determining the savings when using a spray schedule may involve field trials in which different schedules are operated side-by-side for a number of years (12), or savings may be estimated using historical data (11). In order to demonstrate the potential savings of using a weather forecast–based spray schedule, we used South Carolina climatological data with the AUPNUT disease control guidelines to estimate spray application dates for South Carolina's peanut-growing areas. This technique of using historical weather data as if it were a perfect weather forecast and simulating spray decisions can be applied to any spray application scheme that is based on weather forecast parameters.

MATERIALS AND METHODS

Weather and crop data. Temperature and rainfall data for Sumter, Florence, and Blackville, South Carolina, were used as weather factors (17). Crop planting and harvest dates shown in Table 1 were taken from the South Carolina Weekly Weather and Crop Bulletin (16). The starting dates for each year's simulations were determined by adding 10 days to the date when 15% of the crop had been planted (early season planting) and 7 days each to the 50 and 85% planted dates (midseason and late season plantings) to define emergence of plants from the soil. These emergence times consider slower germination in somewhat cooler soils early in the planting season.

The peanut crop is in the field for about 150 days from planting to harvest. Therefore, we ended early planting simulations when 25% of the crop was reported as

Table 1. Day of the year on which 15, 50, and 85% of the South Carolina peanut crop was planted and 25, 50, and 75% was harvested (1980–1990)

	Day of the year										
	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Planted											
15%	119	122	110	122	126	122	117	124	122	127	118
50%	147	132	126	129	132	132	137	140	133	140	133
85%	161	142	133	143	147	151	157	157	151	161	151
Harvested											
25%	284	274	272	260	271	270	289	282	278	265	273
50%	296	284	282	268	278	286	301	293	286	284	285
75%	310	291	291	287	291	298	315	304	298	297	304

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harvested (25% date), midseason planting simulations when 50% of the crop was reported as harvested (50% date), and late season planting simulations when 75% of the crop was reported as harvested (75% date). Simulated spray applications were terminated 14 days prior to the 25, 50, and 75% harvest dates to be consistent with the recommended use of most foliar fungicides labeled for use on peanuts.

Calendar spray guidelines. The Clemson Extension Service's suggested planting dates for peanuts in South Carolina extend from 15 April to 15 May (day 105 to day 135). Thus 15 June (day 166) is suggested as the first spray date for peanut leaf spot control unless the disease appears in the field prior to that time. Subsequent sprays are to be applied on a calendar schedule at 10- to 14-day intervals until 2 weeks prior to harvest, in accordance with label recommendations.

The AUPNUT guidelines. The AUPNUT spray program is initiated when plants emerge. The first spray is applied when one of the following criteria is met: (i) four rain events are counted since emergence and the 5-day forecast indicates 50% or better chance for additional rainfall; (ii) five rain events are counted since emergence and the 5-day forecast indicates 40% or better chance for additional rainfall; or (iii) immediately after six rain events.

Timing for later sprays begins 10 days after the most recent application. Spray is recommended when one of the following criteria is satisfied: (i) no rain has been recorded and the average chance for rain during the next five days is 50% or more; (ii) one rain event is recorded and the average chance for rain during the next five days is 40% or more; (iii) two rain events are recorded and the average chance for rain during the next five days is 20% or more; or (iv) immediately after three rain events.

A rain event in the AUPNUT guidelines is defined as 24-h rainfall amounts of 2 mm (0.1 in) or more, or fog beginning before 8 p.m. In our use of the climatological data, two thresholds for rainfall events were specified. The first threshold was defined as specified in the AUPNUT guidelines, 2 mm. The second was any rainfall in excess of a trace, more than 0.1 mm (0.005 in). The trace level was selected strictly for modeling purposes to determine a maximum number of simulated spray applications each year. Days with fog could not be determined from the climatological database used in this study.

Forecast probabilities. Since actual rainfall observations are used in this simulation instead of weather forecasts, any day with recorded rainfall greater than a trace has a "forecast probability" of 100 percent. Thus one day of rain in five has a probability of 20%; two in five, 40%; three in five, 60%; etc.

RESULTS AND DISCUSSION

Simulated spray applications. Calendar spray applications in each year began on 15 June (day 166), and the AUPNUT applications started when each year's AUPNUT criteria were satisfied. The number of sprays applied for calendar applications with 10 and 14 days between sprays and the number of AUPNUT applications at each location are shown in Tables 2, 3, and 4.

The potential savings if AUPNUT is

Table 2. Number of AUPNUT and calendar schedule foliar fungicide sprays applied to early planted peanuts[a] at three South Carolina locations using two rainfall event definitions[b]

			AUPNUT					
	Calendar schedule		Blackville		Sumter		Florence	
Year	14-day	10-day	>2 mm	>Tr	>2 mm	>Tr	>2 mm	>Tr
1980	8	11	5	7	6	6	7	8
1981	7	10	7	8	7	8	8	8
1982	7	10	7	8	6	8	6	8
1983	6	9	5	6	4	4	4	4
1984	7	10	6	6	4	5	5	7
1985	7	10	7	8	5	7	6	8
1986	8	11	5	7	6	7	6	7
1987	8	11	6	8	5	5	7	8
1988	8	10	6	7	10	10	6	8
1989	7	9	7	8	7	8	5	8
1990	7	10	5	6	5	7	6	8
Total	80	111	66	79	65	75	66	82

[a] Defined as the period between the 15% planted and the 25% harvested dates.
[b] Rainfall in excess of 0.1 mm (Tr) and 2 mm.

Table 3. Number of AUPNUT and calendar schedule foliar fungicide sprays applied to midseason planted peanuts[a] at three South Carolina locations using two rainfall event definitions[b]

			AUPNUT					
	Calendar schedule		Blackville		Sumter		Florence	
Year	14-day	10-day	>2 mm	>Tr	>2 mm	>Tr	>2 mm	>Tr
1980	9	11	6	6	5	6	5	6
1981	8	10	7	8	7	8	8	8
1982	8	10	8	9	7	9	7	9
1983	7	9	6	6	4	4	4	5
1984	8	10	6	7	4	4	5	7
1985	8	10	7	7	6	7	7	7
1986	9	11	6	7	6	8	7	7
1987	9	11	6	7	4	6	5	8
1988	8	10	6	7	7	9	7	8
1989	8	9	8	9	8	9	6	9
1990	8	10	6	6	6	7	5	8
Total	90	111	72	79	64	77	66	82

[a] Defined as the period between the 50% planted and the 50% harvested dates.
[b] Rainfall in excess of 0.1 mm (Tr) and 2 mm.

Table 4. Number of AUPNUT and calendar schedule foliar fungicide sprays applied to late planted peanuts[a] at three South Carolina locations using two rainfall event definitions[b]

			AUPNUT					
	Calendar schedule		Blackville		Sumter		Florence	
Year	14-day	10-day	>2 mm	>Tr	>2 mm	>Tr	>2 mm	>Tr
1980	10	14	6	6	5	5	5	6
1981	8	12	6	8	6	7	7	8
1982	8	12	8	9	7	9	7	8
1983	8	11	7	7	5	5	4	5
1984	8	11	6	6	4	6	5	6
1985	9	12	7	7	6	7	5	7
1986	10	14	5	6	6	8	5	7
1987	9	13	6	7	5	6	4	7
1988	9	12	6	7	6	9	5	6
1989	9	12	7	8	8	9	6	8
1990	9	13	6	6	7	8	5	7
Total	97	137	70	77	65	79	58	75

[a] Defined as the period between the 85% planted and the 75% harvested dates.
[b] Rainfall in excess of 0.1 mm (Tr) and 2 mm.

Table 5. Foliar fungicide applications prior to 15 June following AUPNUT guidelines on early, midseason, and late planted peanuts at three South Carolina locations[a]

	Blackville			Sumter			Florence		
Year	Early	Mid	Late	Early	Mid	Late	Early	Mid	Late
1980	1	0	0	1	0	0	1	0	0
1981	1	1	1	1	1	0	1	1	1
1982	2	1	1	1	1	1	1(2)	1(2)	1
1983	0(1)	0	0	0	0	0	1	1	0
1984	1	1	0	0	0	0	0	0	0
1985	1	1	0	1(2)	0(1)	0	1(2)	1	0
1986	1(2)	0(1)	0	1(2)	1	0	1(2)	0(1)	0
1987	1	1	0	0	0	0	1	0	0
1988	1	1	0	2	1	0	1(2)	1	0
1989	0(1)	0	0	1	1	0	1	0	0
1990	1(2)	1	0	1	0(1)	0	1(2)	1	0
Total	10(14)	7(8)	2	9(11)	5(7)	1	10(16)	6(8)	2

[a] Parentheses indicate total number of sprays when all days with rainfall amounts in excess of a trace (0.1 mm) are considered.

Table 6. Rain episodes and number of AUPNUT spray applications at Sumter, South Carolina, 1980–1990[a]

	Early (15% planted)		Midseason (50% planted)		Late (85% planted)	
Year	Episodes	Sprays	Episodes	Sprays	Episodes	Sprays
1980	18	6	15	5	15	5
1981	19	7	19	7	18	7
1982	28	6	29	7	29	7
1983	13	4	13	4	16	4
1984	18	4	17	4	15	5
1985	22	5	22	6	21	5
1986	26	6	24	6	22	5
1987	22	5	21	4	18	4
1988	28	10	26	7	26	5
1989	18	7	20	8	21	6
1990	23	5	22	6	23	5

[a] An episode is defined as one or more consecutive days with recorded rainfall.

adopted are found by comparing the AUPNUT applications with the calendar applications. The reduction in number of sprays during the 1980–1990 test period compared to a 14-day calendar schedule amounted to about one per year for early plantings (Table 2), two per year for midseason plantings (Table 3), and three per year for late plantings (Table 4). Total sprays saved in this 11-year period depended on location and ranged from 18 to 26 for midseason and from 27 to 39 for late plantings. Early-planting savings were 14 at Blackville and Florence, and 15 at Sumter. When all days with rainfall in excess of a trace were considered in the simulation, savings in spray applications decreased. On the other hand, when time between calendar sprays decreased to 10 days, the savings increased rapidly.

The difference between the number of sprays applied on a calendar schedule and the number of sprays applied on an AUPNUT schedule is caused by two factors: (i) sprays applied on dates earlier than 15 June using the AUPNUT schedule; and (ii) the sequences of consecutive days with rainfall. The number of applications in the AUPNUT schedule prior to the 15 June starting date is shown in Table 5. Values in parentheses are the differences when all rainfall events with more than a trace of rain are taken into account. The greatest impact is on the early-planted crop, with the addition of one spray per year. Midseason and late season plantings are not affected to the same extent. Even though in some years the late planting emerged within a few days of 15 June and the AUPNUT spray schedule did not start until well after that date, there were years in which the AUPNUT spray schedule indicated an application to the late planting prior to 15 June.

The chances for rainfall in South Carolina on any given day during the June through August peanut-growing season range from 35 to 45%. Chances for showers decrease after August to well under 30% by mid-September and to 20% or less during October. Areas in the northern growing area (Florence) have slightly less chance for rainfall than do the southern counties (Blackville). These probabilities do not imply that rainfall is evenly distributed in either time or space. Consequently, sequences of consecutive days with rainfall are likely to occur at any time.

If there is a period in which rain falls each day, the total number of rain days may increase, but the number of sprays may not change if these days are within the 10-day period immediately following a spray application. To demonstrate this, Sumter rainfall episodes (an episode is defined as one or more consecutive days with recorded rainfall) were totaled for each planting–harvest period (Table 6). When there were fewer than 18 episodes from planting to harvest, five or fewer AUPNUT sprays were needed. When there were more than 27 episodes, six to 10 sprays were necessary. It is the middle range of episodes in which the most variation in spray applications occurs. In the Sumter simulation, between four and eight sprays were required when episodes totaled between 18 and 27. Although not shown in this paper, the data for Blackville and Florence were very similar to the Sumter data contained in Table 6. It is these consecutive days with rain that contribute to spray application problems during rainy weather. They also provide a potential to save sprays during dry periods through a weather forecast–based scheduling program such as AUPNUT.

In summary, this study used South Carolina climatological data to simulate several foliar fungicide spray scenarios that may control peanut leaf spot diseases. The study showed that (i) the number of sprays depended on location in the state; (ii) the AUPNUT schedule added one application prior to 15 June on early-planted fields but averaged less than one additional spray per year for later plantings compared to a 14-day calendar-based schedule that started on 15 June; (iii) at least one spray per year can be saved regardless of planting time, and up to five sprays can be saved depending on the distribution of days with rain; and (iv) a simulation using historical weather data can demonstrate potential savings associated with adoption of new application schedules.

Further studies that take advantage of crop models such as PNUTGRO (4) and PEANUT (18) may be of additional help in developing disease control strategies. By combining growth models with models of disease development (13) and using climatological data to drive the models, critical times during the growing season for disease control can be identified. Such studies can assess economic risk associated with various scenarios for both preseason and in-season management decision-making.

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