AU-Pnuts Advisory I: Development of a Rule-Based System for Scheduling Peanut Leaf Spot Fungicide Applications

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ABSTRACT

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The AU-Pnuts advisory was developed to schedule both the initial and subsequent fungicide applications for control of early (*Cercospora arachidicola*) and late (*Cercosporidium personatum*) leaf spots of peanut. The advisory uses the number of days with precipitation greater than 2.5 mm and National Weather Service precipitation probabilities to predict periods favorable for development of early and late leaf spot. Field experiments were conducted from 1989 through 1992 to assess the impact of the AU-Pnuts advisory on early and late leaf spot incidence and yield of Florunner peanut. Use of the AU-Pnuts advisory resulted in a 4-year average of 1.25 fewer fungicide applications than the conventional 14-day schedule. Leaf spot disease control and yields were equivalent to or better than the 14-day schedule. The AU-Pnuts advisory can be used to reduce the number of leaf spot fungicide applications and achieve disease control and yield similar to that with peanuts sprayed on the 14-day schedule.

Early and late leaf spots caused by *Cercospora arachidicola* S. Hori and *Cercosporidium personatum* (Berk. & M. A. Curtis) Deighton, respectively, are among the most important diseases of peanut (*Arachis hypogaea* L.) throughout the world (22). In the peanut production areas of Alabama, Florida, and Georgia, these diseases are primarily controlled by protectant fungicides applied on a calendar schedule. The current recommendation is to initiate fungicide applications 30 to 40 days after planting (DAP) and continue on a 10 to 14 day schedule until 14 days prior to digging (25). However, adequate disease control of peanut leaf spots during periods unfavorable for disease development is possible with fewer sprays than the calendar spray schedule calls for (6,18,21). It is important to develop systems that reduce fungicide use and eliminate unnecessary fungicide applications for economic viability and to minimize the potential impact of pesticides on the environment.

A disease forecasting system (Early Leaf Spot Advisory) was developed in Georgia in 1966, using the duration of relative humidity ≥95% and the minimum temperature during the high humidity period to schedule fungicide applications for control of early leaf spot (13,14). Relative humidity was used in this system as an indirect measurement of leaf wetness (14). This advisory system was later computerized for use in Georgia (19) and Virginia (21). Phipps and Powell (21) reported that the system (81-ADV) has been used successfully in Virginia where early leaf spot predominants. A second advisory system (89-ADV) was developed in Virginia for forecasting early leaf spot and has replaced the old advisory (81-ADV) in Virginia (6). The results of a grower survey found that 94% of peanut growers in Virginia used the 89-ADV (20).

Since the late 1970s, late leaf spot has been the predominant foliar pathogen in Georgia, Florida, and Alabama (25). However, the relative importance of early leaf spot has increased in recent years (4). A new predictive system using an EnviroCaster (Neogen Corp., East Lansing, Mich.) weather monitoring station and microprocessor has been developed in Georgia for late leaf spot (18). The EnviroCaster model schedules fungicide applications based on the accumulation of hours of leaf wetness (18). However, the EnviroCaster requires a large initial monetary investment. We concluded that an easy to use and inexpensive system that forecasts conditions favorable for development of early and late leaf spot was needed for the production areas of Alabama, Florida, and Georgia.

Environmental conditions that favor early and late leaf spot are leaf surface wetness and temperatures above 16°C (1, 13,14,24). Jensen and Boyle (14) reported that periods of leaf wetness exceeding 10 h and minimum temperatures during the wetness period above 21°C are the most crucial conditions for early leaf spot disease development. In growth chambers, maximum infection of peanut leaves by *C. personatum* occurred at 20 C when leaves were exposed to high relative humidity ≥12 h per day (24). Duration of leaf wetness is the single most important environmental variable in forecasting infection periods in the southeastern United States. Temperature is less important because temperatures in this region are commonly favorable for development of both pathogens.

An alternative to measuring leaf wetness duration is to use rainfall as an indirect indicator of leaf wetness. Rainfall is a common cause of leaf wetness and the amount of daily rainfall has been related to duration of leaf wetness (11). Getz (11) reported that the average length of leaf wetness caused by rainfall during June through September was 13.6 hours for three locations in the southeastern United States. Jensen and Boyle (13) found that precipitation commonly occurred before or during periods favorable for peanut leaf spot development. Rainfall amount approximates periods of leaf wetness without the cost of leaf wetness measuring equipment. Another method of indirectly forecasting leaf wetness periods is by using National Weather Service precipitation probabilities. Vincelli and Lorbeer (28) increased the effectiveness of forecasting *Botrytis squamosa* on onion by adding precipitation probabilities into their forecasting model.

For the peanut–early leaf spot–late leaf spot pathosystem, the combination of recorded rainfall and National Weather Service precipitation probabilities were thought to predict potential leaf wetness periods favorable for early and late leaf spot disease development. In addition, by adding precipitation forecasts to the model, growers could be alerted to the need to apply protectant fungicides. Because protectant fungicides are widely used for control of leaf spot, a predictive system should provide warning of periods favorable for disease development so that the grower can apply a fungicide before infection. Analysis of historical weather and disease data revealed that the best daily precipitation amount to predict leaf spot epidemic progress was the number of days with rainfall or irrigation 2.5 mm (9). The objective of this research was to incorporate this variable plus precipitation probabilities into a forecasting system for scheduling the initial and subsequent fungicide applications for control of early and late leaf spots of peanut.

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MATERIALS AND METHODS

Field trials. Experiments were conducted at the Wiregrass Substation of the Alabama Agricultural Experiment Station near Headland, Ala., from 1989 through 1992. The field site in 1989 had been maintained under cultivated summer fallow the previous year. In all other experiments, field sites had been planted to peanut the year before each trial. Planting dates were 8 May 1989, 16 May 1990, 8 May 1991, and 7 May 1992. Nematode, insect, and weed control were according to Cooperative Extension Service recommendations (10). Supplemental irrigation was applied as needed to maintain optimum plant growth. Florunner peanuts were planted in single rows 0.9 m apart at a seedling rate of 112 kg per ha. Plot size was six rows by 11 m in each experiment, except 1989, in which plots were eight rows by 12 m. The experimental design in all experiments was a randomized complete block with six replications per fungicide treatment.

The fungicide used for all treatments was chlorothalonil (Bravo 720, ISK Biosciences Corp., Mentor, Ohio) applied at 1.26 kg a.i. per ha. Fungicide treatments were applied using a tractor-mounted boom sprayer with three hollow cone nozzles (Teejet TX8 nozzles, Spraying Systems Co., Wheaton, Ill.) per row delivering 140 liters of liquid per ha at 413 kPa.

Yield data were collected from the second and third rows of each plot. Peanuts were mechanically inverted, and air dried for 3 to 4 days, then pods were mechanically harvested and dried to approximately 10% moisture before weighing.

1989 field trial. A field experiment was conducted in 1989 in which the following treatments were tested: nonsprayed control, 14-day schedule beginning 37 DAP, and AU-Pnuts advisory 7/3.

The AU-Pnuts Advisory 7/3 was the prototype or initial version of the advisory. In all versions of the AU-Pnuts advisory, the first number refers to the action threshold for the initial fungicide application and the second number refers to the action threshold for subsequent fungicide applications (Table 1). For example, the first fungicide application of the AU-Pnuts 7/3 version was made after recording seven rain events after plant emergence and subsequent fungicide applications were made after three rain events had been predicted or recorded. A rain event is a 24-h period (beginning at 0700 h CST) when ≥2.5 mm of rainfall or irrigation water is recorded, or a ground fog occurs before 2000 h CST the previous evening (9). For all AU-Pnuts advisory treatments, chlorothalonil fungicide sprays were assumed to provide at least 10 days protection from infection by *C. arachidicola* and *C. personatum* (21). Thus, no treatment was applied until at least 10 days had elapsed since the previous application, regardless of rainfall or forecast conditions.

The decision to apply subsequent fungicide was based on the combination of observed rainfall and the 5-day average National Weather Service precipitation probability. Subsequent fungicide applications were made if any combination of 3 observed or predicted days with rain existed (Table 1). Specifically, fungicide was applied if one of the following conditions occurred: no days with rain had been recorded and the 5-day-average precipitation probability was 60%; 1 day with rain had been recorded and the precipitation probability was ≥40%; 2 days of rain had been recorded and average precipitation probability was ≥20%; or 3 days of rain had been recorded. Fungicide applications were discontinued at least 14 days before digging. Five-day precipitation forecasts

Table 1. Treatment schedules for chlorothalonil fungicide evaluated on Florunner peanut for control of early and late leaf spots from 1989 through 1992 in Headland, Ala.

	Subsequent sprays[b]			
	Rain event threshold for each forecast percentile mean			
AU-Pnuts treatment schedule[a]	60 to 100%	40 to 59%	20 to 39%	<20%[c]
1%/3[d]	0	1	2	3
6/3	0	1	2	3
7/2	0	0	1	2
7/3	0	1	2	3
7/4	1	2	3	4
7/6	3	4	5	6
12/2	0	0	1	2
12/3	0	1	2	3
12/4	1	2	3	4
12/6	3	4	5	6

[a] Each treatment schedule was not tested in all years. The first number refers to the number of rain events before the initial fungicide application and the second number refers to the number of recorded or predicted rain events for all subsequent fungicide applications. A rain event is a 24-h period in which ≥2.5 mm of rainfall or irrigation water is recorded, or a ground fog occurs before 2000 h CST the previous evening.

[b] Threshold number of recorded rain events required for each 5-day average precipitation probability range before subsequent fungicide applications were applied. After each fungicide application, a 10-day period was observed before monitoring rain events and precipitation probabilities.

[c] Subsequent fungicide applications made immediately after recording this number of rain events regardless of 5-day precipitation probability.

[d] Critical disease level of 1% leaflets with lesions (2).

Table 2. Effect of fungicide schedule on peanut leaf spot development and yield of Florunner peanut in Headland, Ala. during 1989 and 1990

Year/fungicide schedule[a]	No. of sprays[b]	Final incidence (%)[c]	AUINFC[d] % infection	AUDEFC[e] % defoliation	Pod yield (kg per ha)
1989					
Nonsprayed Control	0	85.0	4,454.7	3,465.2	3,151
14-Day Schedule	7	49.7	2,590.1	2,070.8	3,693
AU-Pnuts Advisory 7/3	6	55.1	2,465.2	2,090.3	3,828
LSD ($P \leq 0.05$)		8.6	279.6	227.5	654
1990					
14-Day Schedule	6	16.3	590.3	500.5	2,060
AU-Pnuts Advisory 1%/3	4	11.7	489.8	474.7	1,835
AU-Pnuts Advisory 7/2	5	19.1	740.5	610.9	2,160
AU-Pnuts Advisory 7/3	4	19.8	752.0	629.3	2,312
AU-Pnuts Advisory 7/4	3	26.7	921.3	701.6	2,331
AU-Pnuts Advisory 7/6	2	28.6	1,049.8	809.2	2,304
AU-Pnuts Advisory 12/2	3	30.2	1,345.1	1,012.3	2,246
AU-Pnuts Advisory 12/3	3	28.9	1,247.5	887.1	2,470
AU-Pnuts Advisory 12/4	3	30.9	1,196.9	882.2	2,133
AU-Pnuts Advisory 12/6	1	47.5	1,457.8	1,048.2	2,605
LSD ($P \leq 0.05$)		6.4	229.4	188.3	564

[a] Fungicide schedule. For all AU-Pnuts advisory treatments the first number refers to the number of recorded rain events before the initial spray and the second number refers to the number of predicted or recorded rain events before all subsequent sprays. A rain event is a 24-h period in which ≥2.5 mm of rainfall or irrigation water is recorded, or a ground fog that occurs before 2000 h CST the previous evening.

[b] Number of applications of the fungicide chlorothalonil (1.26 kg a.i. per ha).

[c] Final leaf spot incidence (percent leaflets with lesions) assessed on 20 September 1989 and 4 September 1990, for respective years.

[d] Area under the season-long disease progress curve for percent infected leaflets.

[e] Area under the season-long disease progress curve for percent defoliated leaflets.

were obtained from the National Weather Service. Daily precipitation data were collected at 0700 h CST using a Tru-Check rain gauge (Edwards Manufacturing Co., Albert Lea, Minn.). The gauge was positioned 1.2 m above the ground and was located at the edge of the experimental site.

1990 field trial. The number of AU-Pnuts advisory treatments was expanded in 1990 to more accurately determine the timing of both initial and subsequent sprays. Ten fungicide schedules were evaluated in 1990: nonsprayed control; AU-Pnuts advisory 1%/3; 7/2; 7/3; 7/4; 7/6; 12/2; 12/3; 12/4; and 12/6 (Table 1). The first fungicide application of the AU-Pnuts 1%/3 treatment was applied after a critical disease level of 1% of leaflets with lesions was observed in the field (2,28). Critical disease levels were determined by biweekly leaf spot assessments of nonsprayed plots. During each assessment, five plants in each plot were nondestructively sampled to determine the percentage of leaflets with lesions (9).

1991 field trial. Data collected in 1990 in a nonrotated field indicated that when application of the first spray occurred after 7 days with rainfall ≥2.5 mm, it was after the critical disease level of 1% had been exceeded. Therefore, AU-Pnuts 6/3 version of the advisory was evaluated in 1991. This advisory schedule used a six-rain-event threshold for the initial fungicide application rather than a seven-rain-event threshold. The Early Leaf Spot Advisory developed for early leaf spot (14, 19,21) was also evaluated. Fungicide applications were made after a favorable Early Leaf Spot Advisory was issued by the National Weather Service for Dothan, Ala. However, fungicide applications scheduled using the Early Leaf Spot Advisory were not made at intervals of less than 10 days (21). These two treatments (AU-Pnuts 6/3 and Early Leaf Spot Advisory) were evaluated in addition to a 14-day schedule beginning 37 DAP, AU-Pnuts 7/2, AU-Pnuts 7/3, and AU-Pnuts 7/4.

1992 field trial. The number of AU-Pnuts advisory treatments was reduced in 1992 to those versions of the advisory previously proven to provide the best disease control. Four treatments were tested: nonsprayed control; 14-day schedule (beginning 40 DAP); AU-Pnuts 6/3; and the Early Leaf Spot Advisory.

Disease assessments. The incidence of peanut leaf spot was monitored periodically throughout the duration of each experiment. Estimates of percent leaflets with lesions were made by removing the main stem of five selected plants from each plot (9). We counted the number of nodes with expanded leaves, number of defoliated leaflets, and number of leaflets on each stem. Lesions of early and late leaf spots were not differentiated. Percent infected and defoliated leaflets were calculated as described by Davis et al. (9). Early-season postemergence herbicide damage and defoliation caused by paraquat (Starfire, Zeneca Inc., Richmond, Calif.) was prevented in these experiments by using pyridate (Tough, Agrolinz Inc., Memphis, Tenn.) instead of paraquat. The area under the season-long disease progress curve for percent infected (AUINFC) and defoliated leaflets (AUDEFC) was calculated for each plot (23). Disease and yield data were subjected to analysis of variance and mean comparisons if F values were significant ($P \leq 0.05$) using Fisher's protected least significant difference (LSD) test (5,27).

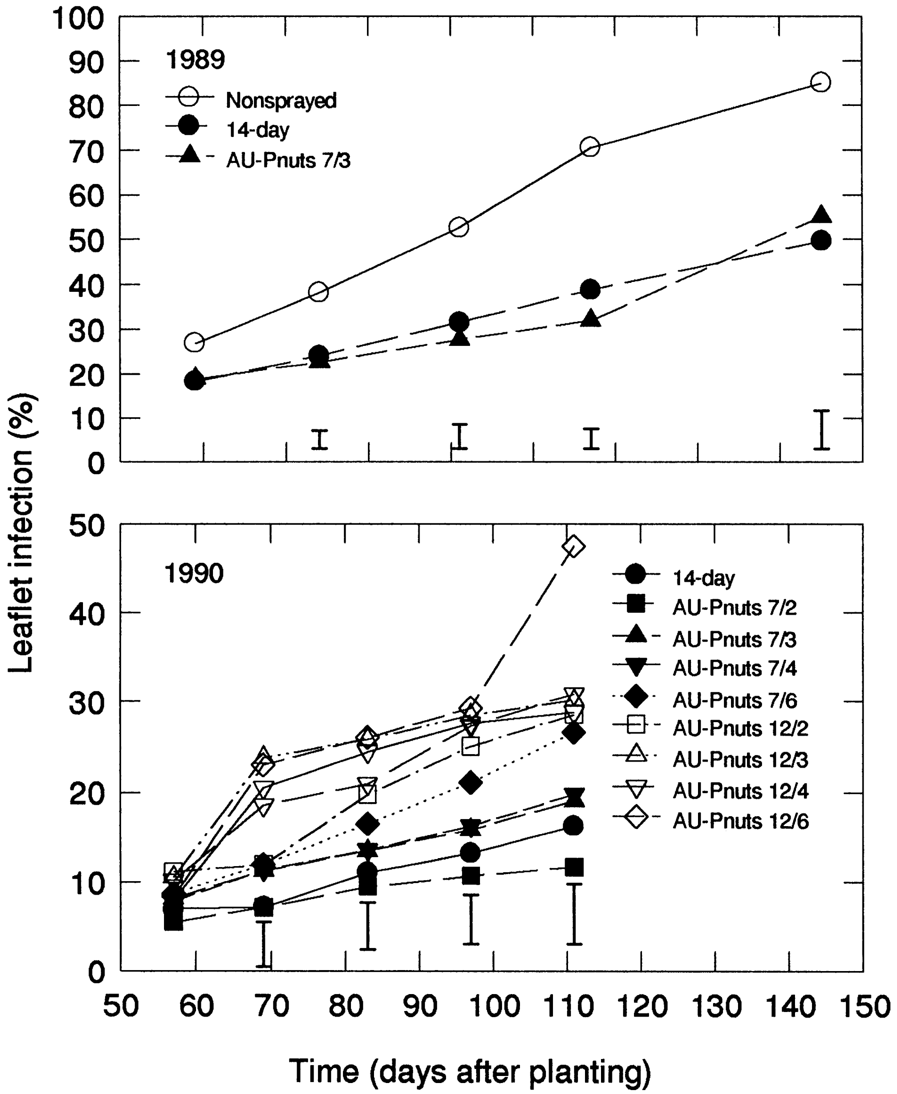

Fig. 1. Early and late leaf spot disease progress curves for Florunner peanut treated with chlorothalonil (1.26 kg a.i. per ha) applied according to various fungicide schedules at Headland Ala., during 1989 and 1990. See text for complete explanation of fungicide schedules. Vertical bars indicate Fisher's protected least significant difference ($P \leq 0.05$) for comparing fungicide schedules within each sampling date.

RESULTS

1989 field trial. The 1989 growing season was characterized by above normal rainfall, which is reflected in high final disease incidence, AUINFC, and low yields of the nonsprayed treatment compared with fungicide treated plots (Table 2 and Fig. 1). Final disease incidence, AUINFC, AUDEFC, and yields differed among treatments. The 14-day schedule and AU-Pnuts 7/3 treatments were effective in managing peanut leaf spot with seven and six sprays, respectively (Table 2). There were no significant differences between the 14-day schedule and the AU-Pnuts 7/3 for AUINFC, AUDEFC, and final disease incidence (Table 2). Yields of the 14-day schedule and AU-Pnuts 7/3 were significantly higher than those of the nonsprayed control (Table 2).

1990 field trial. Disease incidence was lower throughout the season than in 1989 due to a severe mid- to late-season drought (Table 2). Although peanuts were irrigated, yields were 47% lower in 1990 compared with yields in 1989. No AU-Pnuts advisory treatment had higher yields than the 14-day schedule (Table 2). All four variations of the AU-Pnuts advisory had fewer sprays than the 14-day schedule, with five, four, three, and four sprays for the AU-Pnuts 7/2, 7/3, 7/4, and 1%/3 treatments, respectively (Table 2). The AU-Pnuts 1%/3 treatment scheduled the first application on 19 June compared with 5 July for the AU-Pnuts 7/3 treatment. Final leaf spot incidence, AUINFC, and AUDEFC were all higher ($P \leq 0.05$) for the AU-Pnuts 7/3 treatment than for the AU-Pnuts 1%/3 treatment.

1991 field trial. The 1991 growing season was characterized by normal rainfall until the last month of the season when there was an extended dry period. Disease incidence was moderate with differences among treatments in final disease incidence, AUINFC, AUDEFC, and yield (Table 3 and Fig. 2). The predominant foliar pathogen was late leaf spot. However, moderate amounts of early leaf spot were also present. All fungicide schedules, except AU-Pnuts 7/2, saved one or more sprays compared with the 14-day schedule (Table 3). Final disease severity, AUINFC, and AUDEFC were all higher with the AU-Pnuts 7/4 treatment than with all other fungicide schedules (Table 3). Season-long disease control (AUINFC) was better for the AU-Pnuts 6/3 treatment, with one less spray, compared with the standard 14-day schedule.

1992 field trial. Above normal rainfall for the majority of the growing season prevented advisory schedules from reducing the total amount of fungicide sprays compared with the 14-day schedule (Table 3). The Early Leaf Spot Advisory recommended eight, compared with seven sprays for both the 14-day schedule and AU-Pnuts advisory. Final disease incidence was greater than 90% in nonsprayed plots. The predominant foliar pathogen in this trial was early leaf spot with late leaf present in only trace amounts. The season-long disease control (AUINFC and AUDEFC) was significantly better for the AU-Pnuts advisory than for the Early Leaf Spot Advisory. The additional application made by the Early Leaf Spot Advisory did not improve disease control compared with either the AU-Pnuts advisory or calendar schedule.

DISCUSSION

The AU-Pnuts advisory scheduled the initial and subsequent fungicide applications for the control of early and late leaf spot. This advisory is inexpensive, requiring only a tapered rain gauge that accurately measures increments of 2.5 mm and a 5-day precipitation forecast, which can be obtained by calling a toll-free telephone number. The use of National Weather Service precipitation forecasts allowed for timely application of protectant fungicides and prevented problems with implementation of recommended sprays due to adverse weather conditions.

The results of field trials from 1989 through 1992 showed that the AU-Pnuts 1%/3, 7/3, and 6/3 treatments were equivalent to or better than the 14-day schedule. In addition, these treatments required fewer sprays than the 14-day schedule in all trials except 1992. The 6/3 treatment is the current version of the model we have named the AU-Pnuts advisory. This treatment was chosen over the 1%/3 treatment due to the difficulty in accurately determining the 1% level of leaf spot incidence. Determining the 1% disease level is also time-consuming, expensive, and may give less advanced warning for fungicide applications. In 2 years of testing, the AU-Pnuts advisory 6/3 had the same or better leaf spot control with equal or fewer fungicide applications compared with the Early Leaf Spot Advisory (14,19,21). Smith et al. (26) also found that the Early Leaf Spot Advisory did not reduce the number of fungicide applications compared with the 14-day schedule.

Other versions of our model were tested with more or fewer recorded or predicted precipitation events for timing subsequent sprays. The AU-Pnuts 7/2 version of the model provided excellent and consistent control, but increased fungicide use and expense did not increase pod yield. The AU-Pnuts 7/4 version of the model did not provide satisfactory disease control or improved yields.

Both early and late leaf spot can cause peanut yield losses in the southeastern U.S. (4,25). This suggests that an advisory system for this region needs to be able to manage both pathogens. In our trials, late leaf spot was the predominant pathogen in 1989 and 1990, early leaf spot was the predominant pathogen in 1992, and early and late leaf spot were present in nearly equal proportions in 1991. The advisory performed equally well during experiments (1989 and 1990) in which late leaf spot was the predominant pathogen, and those in which early leaf spot was the predominant pathogen (1992).

The economic benefits of using the AU-Pnuts advisory are derived from a combination of increased yields and reduced leaf spot diseases control costs. The average increase in net return for the AU-Pnuts advisory was $137.84 per ha compared with the 14-day schedule during a 3-year period (12). From 1989 through 1992, the AU-Pnuts advisory increased yields compared with the 14-day schedule in three of four trials, with an average increase of 180 kg/ha. Similar results have been obtained in on-farm demonstration trials using the advisory system (3). In these trials, the AU-Pnuts advisory increased yields in 80% of the trials, with an average increase of 289 kg per ha (3).

Forecasting systems as a way to reduce unnecessary fungicide applications have been developed for many crops, e.g., apple (15), onion (28), peanut (6,14,18,21), and potato (16,17). The AU-Pnuts advisory provides a rule-based method for leaf spot fungicide applications based on the prediction of potential favorable conditions for leaf spot development instead of on calendar scheduling. Thus, under very fa-

Table 3. Effect of fungicide schedule on peanut leaf spot development and yield of Florunner peanut at Headland, Ala. in 1991 and 1992

Year/fungicide schedule[a]	No. of sprays[b]	Final incidence (%)[c]	AUINFC[d] % infection	AUDEFC[e] % defoliation	Pod yield (kg per ha)
1991					
14-Day Schedule	7	37.5	1,788.8	1,402.1	3,662
Early Leaf Spot Advisory[f]	6	37.3	1,627.1	1,376.7	4,066
AU-Pnuts Advisory 7/2	7	24.8	1,452.5	1,236.7	3,919
AU-Pnuts Advisory 7/3	6	33.9	1,548.3	1,312.1	4,151
AU-Pnuts Advisory 7/4	4	56.0	2,018.3	1,540.2	4,081
AU-Pnuts Advisory 1%/3	6	38.1	1,726.8	1,443.7	4,003
AU-Pnuts Advisory 6/3	6	33.2	1,496.2	1,267.7	4,321
LSD ($P \leq 0.05$)		9.6	249.6	150.4	503
1992					
Nonsprayed Control	0	93.6	3,496.6	2,424.0	3,996
14-Day Schedule	7	42.2	1,705.0	1,356.0	4,592
Early Leaf Spot Advisory	8	29.9	1,591.9	1,326.2	4,616
AU-Pnuts Advisory 6/3	7	29.6	1,410.5	1,187.5	4,592
LSD ($P \leq 0.05$)		5.7	129.7	80.1	368

[a] Fungicide schedule. For all AU-Pnuts advisory treatments the first number refers to the number of recorded rain events before the initial spray and the second number refers to the number of predicted or recorded rain events before all subsequent sprays. A rain event is a 24-h period in which ≥2.5 mm of rainfall or irrigation water is recorded, or a ground fog occurs before 2000 h CST the previous evening.

[b] Number of applications of the fungicide chlorothalonil (1.26 kg per ha).

[c] Final leaf spot incidence (% leaflets with lesions) assessed on 27 September 1991 and 17 September 1992, for each respective year.

[d] Area under the season-long disease progress curve for percent infected leaflets.

[e] Area under the season-long disease progress curve for percent defoliated leaflets.

[f] Early Leaf Spot Advisories (9,11,13) were obtained from the National Weather Service for the Dothan, Ala., reporting station.

vorable conditions for leaf spot development, the AU-Pnuts Advisory may increase the number of fungicide sprays above that for a calendar spray program to reduce the risk of disease outbreaks. This system provides a rule-based method to adjust application schedules to coincide with weather conditions that drive peanut leaf spot epidemics.

The AU-Pnuts advisory is designed to manage the two most important foliar diseases of peanut that occur in the southeastern U.S. The advisory has been tested with excellent results by research cooperators in Georgia (A. K. Culbreath, *personal communication*), Florida (F. M. Shokes, *personal communication*), and Oklahoma (7,8). In addition, the system was tested in 10 on-farm trials in 1991 (3). In nearly every case, the AU-Pnuts advisory called for fewer fungicide applications than the calendar schedule with no loss in disease control or yield compared with conventional leaf spot application schedules.

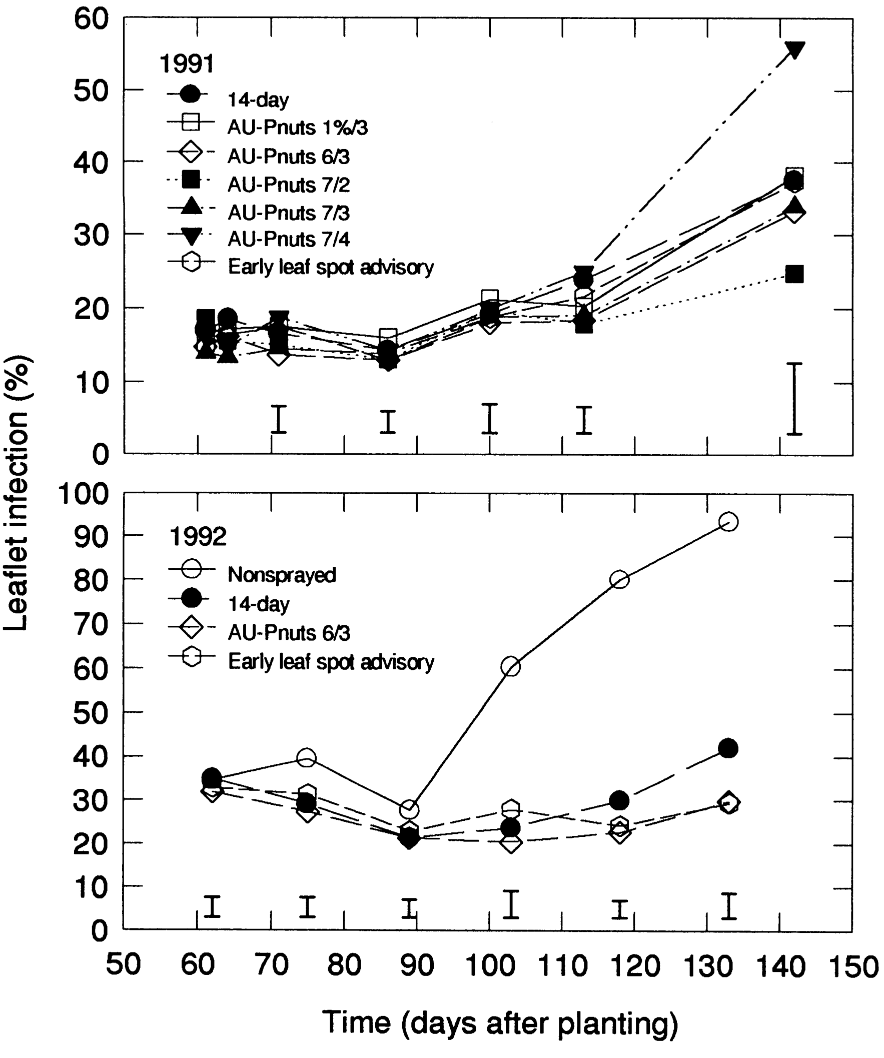

Fig. 2. Early and late leaf spot disease progress curves for Florunner peanut treated with chlorothalonil (1.26 kg a.i. per ha) applied according to various fungicide schedules at Headland Ala., during 1991 and 1992. See text for complete explanation of fungicide schedules. Vertical bars indicate Fisher's protected least significant difference ($P \leq 0.05$) for comparing fungicide schedules within each sampling date.

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