Evaluation of a Weather-Based Spray Advisory for Management of Early Leaf Spot of Peanut in Oklahoma[1]

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ABSTRACT

A simplified version of the weather-based advisory program developed by Parvin, Smith, and Crosby (PSC) for scheduling fungicide sprays for management of early leaf spot (*Cercospora arachidicola* Hori) of peanut (*Arachis hypogea* L.) was evaluated under various productions systems in Oklahoma from 1990-1992. Over eight trials with spanish cultivars, the number of sprays per season averaged 5.7 for the 14-d schedule and 4.0 for the advisory program. Final disease incidence (symptomatic and defoliated leaflets) with the fungicide chlorothalonil (1.26 kg/ha) averaged 15% for the 14-d schedule, 34% for the advisory program, and 77% for the control. However, disease incidence (75%) and defoliation (50%) approached unacceptable levels on the spanish cultivars in some trials. In six trials with runner cultivars, the number of sprays averaged 6.7 for the 14-d schedule and 4.7 for the advisory program. Final disease incidence with chlorothalonil on the runner cultivars averaged 5% for the 14-d schedule, 14% for the advisory program, and 68% in the control. Yields did not differ in any of the 14 trials between the advisory and 14-d programs using chlorothalonil. Yields averaged 3015, 3003, and 2303 kg/ha for spanish cultivars and 4108, 3855, and 3066 kg/ha for runner cultivars with the 14-d schedule, advisory program, and control, respectively. The advisory program was effective in irrigated trials where weather stations were deployed either under or outside the influence of irrigation. The fungicides tebuconazole at 0.14 kg/ha and propiconazole at 0.13 kg/ha generally provided better leaf spot control with the advisory program than chlorothalonil. The post-infection activity of these fungicides was observed in one trial and probably accounts for their improved performance. Yields were reduced and leaf spot incidence was high where tank mixes of benomyl (0.28 kg/ha) or thiophanate-methyl (0.38 kg/ha) plus mancozeb (1.68 kg/ha) were used with the advisory program. Area under the disease progress curve, leaf spot incidence, and defoliation in the controls were lower for runner than for spanish cultivars at sites where both market types were planted in adjacent trials. Fungicides applied according to the advisory program provided better leaf spot control on the runner cultivars. Results showed the need for a weather-based advisory which allows greater levels of leaf spot control on spanish cultivars than the PSC advisory.

Key Words: *Arachis hypogaea*, *Cercospora arachidicola*, fungicides, early leaf spot, runner cultivars, spanish cultivars.

Early leaf spot, caused by *Cercospora arachidicola* Hori, is the principal foliar disease of peanut (*Arachis hypogaea* L.) in Oklahoma. Other foliar diseases such as late leaf spot (*Cercosporidium personatum* Berk. & Curt.), rust (*Puccinia arachidis* Speg.), and pepper spot and leaf scorch (*Leptosphaerulina crassiasca* (Sechet) Jackson & Bell) are rarely encountered and are presently of minor importance. Web blotch (*Phoma arachidicola* Marasas, Pauer, & Boerema) can be damaging on spanish cultivars in isolated production areas. Growers in the state have long recognized the damaging effects of early leaf spot and currently manage the disease with preventive fungicide applications on a 14-d schedule.

Infection by *C. arachidicola* and subsequent development of early leaf spot of peanut are greatly influenced by weather. Jenson and Boyle determined that the hours of relative humidity (RH) $\geq$95% and the minimum temperature (T) during the high humidity period could be used to forecast leaf spot increase and modeled this relationship (10,11). The Jenson and Boyle model was later computerized and adapted to schedule fungicide sprays by Parvin *et al.* (18). The Parvin, Smith, and Crosby (PSC) advisory was validated for virginia cultivars in Virginia (20) where it was used commercially from 1981-1988. An average of 4.5 fewer sprays per season were applied using the advisory compared to the 14-d schedule and the costs of leaf spot control were reduced by $71 to 97/ha (12). In North Carolina, the advisory was simplified to make it easier to use and has been deployed since 1983 (4).

Previous studies with the PSC advisory have shown that while yields do not differ between the advisory and 14-d spray programs, leaf spot incidence is often higher with the advisory (5,15,20). The high incidence of leaf spot has concerned growers and has been responsible for renewed efforts in improving advisory models. A new advisory program was released in Virginia for replacement of the PSC

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advisory in 1989 (5). This new model is based on detailed studies of the effects of temperature and relative humidity on sporulation, conidial germination, infection, and symptom expression (1,2,3). Advantages of the new Virginia advisory include improved control of leaf spot and adaptability for use with cultivars that differ in disease reaction or fungicides with different efficacy (5). This advisory has enabled growers in Virginia to reduce fungicide applications by an average of 2.25 per season (19). Another advisory program has been recently developed, based on observed correlations of rainfall and leaf spot epidemics (6,13). This program utilizes actual and probable rainfall in scheduling fungicides for control of both early and late leaf spot (7).

The protective fungicide, chlorothalonil (tetrachloroisophthalonitrile), has been most often used in trials evaluating performance of advisory programs. Sterol biosynthesis inhibitors (SBI) such as propiconazole (1-[[2-(2,4-dichlorophenyl)-4-propyl-1,3-dioxolan-2-yl]methyl]-1H-1,2,4-triazole) and tebuconazole (µ-[2-(4-chlorophenyl)ethyl]-µ-(1,1-dimethyl-ethyl)-1H-1,2-4-triazole-1-ethanol) represent a new class of systemic fungicides. Propiconazole and tebuconazole have recently been registered for control of early and late leaf spot of peanut. SBI fungicides may offer advantages over protective fungicides in advisory programs because of post-infection activity (22).

Differences between peanut production systems in the Virginia/Carolina area and Oklahoma dictate that the utility of any leaf spot advisory should be evaluated before commercial implementation in Oklahoma. In Virginia/Carolina, virginia-type cultivars are grown and most of the acreage in not irrigated. Production systems in Oklahoma are more variable where 70% of the acreage is irrigated. Irrigation increases the incidence of several peanut diseases in Virginia including early leaf spot (21). In the Southwest, some assume that irrigation prolongs leaf wetness to an extent that mandates monitoring of weather conditions within individual fields. Reports on the effectiveness of leaf spot advisories in irrigated peanuts are lacking.

The acreage in Oklahoma is divided between runner (30%) and spanish (70%) cultivars. Runner cultivars (e.g. Florunner) appear more resistant to early leaf spot than many spanish cultivars (8,9,17). The yield response of the spanish cultivar Pronto to fungicide sprays was greater than that of Florunner (17). Less sporulation of *C. arachidicola* and fewer lesions per leaf were observed on Florunner compared to the spanish cultivars Comet or Tamnut 74 (8). Florunner and the virginia cultivar Florigiant had fewer lesions per leaf and less defoliation than the spanish cultivar Starr (9). Modifications of advisory programs have been suggested for cultivars differing in leaf spot reaction (5,15).

The objective of this study was to evaluate the effectiveness of the PSC advisory in scheduling fungicide sprays over several years and locations under the varying production systems in Oklahoma. In addition, advisory performance using SBI fungicides was compared with that of chlorothalonil.

Materials and Methods

In 1990 and 1991, the advisory and 14-d spray programs using chlorothalonil were compared in six trials with either runner or spanish cultivars (Table 1). The site at Perkins was on an experiment station while the other sites were commercial fields. At each site; an untreated control and treatments with chlorothalonil at 1.26 kg/ha according to the advisory and 14-d programs were tested.

In 1991 and 1992, the effects of spray program and fungicide were evaluated on runner and spanish cultivars, each planted in adjacent trials at four sites (Table 1). In addition to those described above, treatments at one or more sites included 0.14 kg/ha tebuconazole (advisory and 14-d programs), 0.13 kg/ha propiconazole (advisory program), a tank mix of 0.28 kg/ha benomyl (methyl 1-(butylcarbamoyl)-2-benzimidazolecarbamate) plus 1.68 kg/ha mancozeb (coordination product of Zn^{++} and manganese ethylene-bisdithiocarbamate, advisory program), and a tank mix of 0.38 kg/ha thiophanate-methyl (dimethyl[(1,2-phenylene)-bis(iminocarbonothioyl)]bis[carbamate]) plus 1.68 kg/ha mancozeb (advisory program). The adjuvant Penetrator (light to mid range paraffin base petroleum oil + polyol fatty acid esters + polyethoxylated derivatives thereof) was added at 0.25% of the spray mixture to tebuconazole and the two tank-mix treatments. Irrigated trials (Table 1) received sprinkler irrigation as necessary to prevent moisture stress. Except for leaf spot treatments, recommended crop and pest management practices were followed (24).

A simplified version of the PSC advisory was used in this study because of its history of success in North Carolina and daily advisories could be calculated quickly without the aid of a computer (4). Briefly, daily infection indices from 0 to 3, where 0=unfavorable and 3=very favorable, were obtained from the PSC nomogram using the period of RH $\geq$95% and the minimum T during the period as input variables. The nomogram was adjusted to increase the infection index by 0.5 along T/RH combinations that bordered a higher infection index. A 2-d sum of daily infection indices $\geq$3.5 was used as the spray threshold.

T and RH were continuously monitored at a height of 1.2 m from late June or early July through harvest at or near each site. Hygrothermographs (Qualimetrics, Inc., Sacramento, CA) housed in weather shelters were used at all sites except Perkins and Ft. Cobb where CR21X dataloggers (Campbell Scientific, Logan, UT) equipped with fan psychrometers were used. The weather stations were situated above various types of vegetation in field borders either under irrigation (Perkins, Ft. Cobb, and Wetumka) or away from irrigation (Burneyville in 1991 and 1992 and Coleman). At Calera in 1990, the station was in the border of a dryland field ca. 5 km from the two trial sites. In 1991, the Calera station was in an irrigated border of the trial with Spanco and ca. 5 km from the trial with Florunner.

Plots, consisting of four 7.6-m-long rows spaced 0.91 m apart except at Burneyville where rows were 9.1-m long, were arranged in four randomized complete blocks. Treatments were applied to each plot with a wheelbarrow sprayer equipped with three 8002 flat-fan nozzles per

Table 1. Description of trial sites and practices used in the evaluation of spray programs for control of early leaf spot.

Site-year	Previous crop	Cultivar	Fungicide tested[a]	Plant date	Irrigation (+/-)[b]	Harvest date (DAP[c])
Perkins-1990	Peanut	Spanco[d]	C	18 May	+	12 Oct (147)
Calera-1990	Peanut	Florunner[e]	C	20 May	+	13 Nov (177)
Coleman-1990	Peanut	Pronto[d]	C	17 May	-	14 Sep (120)
Calera-1990	Peanut	Spanco	C	25 May	-	28 Sep (126)
Calera-1991	Sorghum	Spanco	C	29 May	+	18 Oct (142)
Calera-1991	Peanut	Florunner	C	11 May	+	6 Nov (179)
Burneyville-1991	Peanut	Spanco	C,T	23 May	+	8 Oct (138)
		Okrun[e]	C,T	23 May	+	5 Nov (166)
Ft. Cobb-1991	Peanut	Spanco	C,T	21 May	+	7 Oct (139)
		Florunner	C,T	21 May	+	17 Oct (149)
Wetumka-1991	Peanut	Spanco	C,T	14 May	+	26 Sep (135)
		Okrun	C,T	14 May	+	9 Oct (148)
Burneyville-1992	Peanut	Spanco	C,P,T,BM,TM	14 May	+	9 Oct (148)
		Okrun	C,P,T,BM,TM	14 May	+	12 Nov (182)

[a]C=chlorothalonil, P=propiconazole, T=tebuconazole, BM = benomyl + mancozeb, TM = Thiophanate-methyl+mancozeb.

[b]+ = irrigated, - = dryland.

[c]Days after planting

[d]Spanish cultivar

[e]Runner cultivar.

row. The sprayer was calibrated to deliver 362 L/ha at 275 kPa. The first application for both 14-d and advisory programs was made about 45 d after planting (DAP). Thereafter, advisory treatments were applied within 4 d of a favorable advisory, but not within 10 d of the previous spray. Spray programs were maintained until 2 to 3 wk before anticipated harvest, but labor scheduling and weather limitations resulted in some harvest delays and a range of 2 to 6 wk before actual harvest.

The incidence of leaf spot was recorded at ca. 14-d intervals beginning on the first spray date. Visual estimates of leaf spot incidence (percent symptomatic and defoliated leaflets) were made in three, randomly selected, 1-m segments of row in each of the two center rows of plots. Diagrams of various levels of leaf spot incidence were used as a guide in the estimations. Final estimates of leaf spot incidence and leaflet defoliation were recorded at or near harvest. The incidence of other diseases such as Aspergillus crown rot (*Aspergillus niger*), limb rot (*Rhizoctonia solani*), southern blight (*Sclerotium rolfsii*), and Sclerotinia blight (*Sclerotinia minor*) were also recorded at or near harvest. The number of 15-cm segments of row with symptomatic plants were counted in the center two rows and counts were converted to the percentage of total row length. Yields were taken from the center two rows of each plot. Plots were dug and inverted, dried in windrows for 2 to 3 d, and pods were removed from vines with a stationary thresher. Pods were dried to ca. 10% moisture and cleaned to remove foreign material before weighing.

Analyses of leaf spot incidence data used the mean of the six samples per plot. Area under the disease progress curve (AUDPC) was calculated according to Shaner's formula (23). Simple correlation coefficients were computed to assess the contribution of leaf spot to variation in yield (25). Disease incidence and yield data were subjected to analysis of variance and where treatment effects were significant ($P \leq 0.05$), means were separated with Fisher's Protected Least Significant Difference (LSD) test (25). The LSD test was not applied where one or more means had no variance (mean=0). Only significant correlations and mean differences ($P \leq 0.05$) are described unless otherwise stated.

Results

Incidence of early leaf spot, the only foliar disease encountered in the study, varied between trials. Differences in leaf spot incidence but not yield were apparent in comparisons of the advisory and 14-d programs using chlorothalonil in 1990 and 1991 (Table 2). Leaf spot incidence and AUDPC for the advisory program were less than the control, but greater than the 14-d schedule at Perkins-1990 on Spanco, Calera-1990 on Spanco, and Calera-1991 on Florunner. Leaf spot incidence on Spanco in advisory plots at Perkins-1990 increased late in the season to over 70% (Fig. 1). Leaf spot incidence and AUDPC for advisory and 14-d programs were similar in the other trials. Yield and AUDPC were correlated at Perkins-1990 for Spanco (r=-0.62) and Calera-1991 for Florunner (r=-0.71), but not in the other four trials. Likewise, leaf spot reduced yield of the control compared to advisory and 14-d treatments at Perkins-1990 for Spanco and Calera-1991 for Florunner. Drought stress caused permanent wilt which resulted in low yields of the spanish cultivars in the dryland trials at Coleman-1990 and Calera-1990. Two or three fewer sprays were applied per season with the advisory compared to the 14-d program. At Calera-1990 on Florunner, Aspergillus crown rot reduced yields (r=-0.69), but treatments had no effect on incidence which ranged from 14 to 19%. At Calera-1991, low levels of southern blight (<5%) developed which were not correlated with yield. At Perkins-1990, the incidence of southern blight (11-14%) and Sclerotinia blight (2-4%) was not affected by treatment and was not correlated with yield.

Where spray programs and fungicides were compared in 1991, advisory treatments of either chlorothalonil or tebuconazole resulted in yields equivalent to the 14-d schedule of chlorothalonil on both market types of peanut (Table 3). However, differences in leaf spot incidence were apparent for both fungicide and spray program. Sprays of tebuconazole according to the advisory program on Spanco at Burneyville-1991 reduced leaf spot incidence, defoliation, and AUDPC compared to sprays of chlorothalonil on either the 14-d or advisory program. In the adjacent trial planted to Okrun, leaf spot development was delayed by three weeks and fungicides provided better disease control (Fig. 1). Tebuconazole treatment of Okrun using the advisory reduced leaf spot incidence compared to chlorothalonil, but levels of defoliation were minimal (Table 3). AUDPC and yield at Burneyville-1991 were correlated for both Spanco (r=-0.82) and Okrun (r=-0.90). Leaf spot reduced yields of untreated Spanco and Okrun by an average of 45 and 32%, respectively.

Results at Wetumka-1991 were similar to Burneyville-1991 except that disease incidence, defoliation, and AUDPC for Spanco treated with tebuconazole using the advisory were higher than for both spray programs using chlorothalonil and the 14-d schedule with tebuconazole (Table 3). Leaf spot incidence and AUDPC were also greater for advisory treatments of the two fungicides compared to the respective 14-d treatments for Spanco, but

Table 2. Comparison of spray programs using chlorothalonil at 1.26 kg/ha for control of early leaf spot on spanish and runner cultivars of peanut at six sites in Oklahoma in 1990-1991.

Site-year	Cultivar	Spray program	Spray	Leaf spot incidence[a]	Defoliation[b]	AUDPC[c]	Yield
			no.	—%—			kg/ha
Perkins-1990	Spanco[d]	14-d	6	8	0	321	3641
		Advisory	3	77	10	1761	3723
		Control	0	98	81	3709	2848
LSD[e]				8	-	351	424
Calera[f]-1990	Spanco	14-d	5	5		179	732
		Advisory	3	18		316	732
		Control	0	46		932	732
LSD				12		462	ns
Calera-1990	Florunner[g]	14-d	7	0	0	16	2461
		Advisory	4	2	0	91	2868
		Control	0	58	25	1652	2624
LSD				-	-	633	ns
Coleman[f]-1990	Pronto[d]	14-d	5	2		86	1078
		Advisory	3	5		100	1119
		Control	0	52		734	814
LSD				13		270	ns
Calera-1991	Spanco	14-d	7	1	0	23	3417
		Advisory	5	2	0	59	3702
		Control	0	60	13	680	3275
LSD				15	-	149	ns
Calera-1991	Florunner	14-d	7	14	5	867	4292
		Advisory	5	33	15	1547	3946
		Control	0	83	59	3055	2339
LSD				8	9	452	970

[a]Final estimations of percent symptomatic and defoliated leaflets.
[b]Final estimations of percent defoliated leaflets.
[c]Area under the disease progress curve.
[d]Spanish cultivar.
[e]Fisher's Least Significant Difference test at P<0.05. ns = no significant difference. - = not analyzed because one or more means had no variance.
[f]Dryland sites, all others were irrigated.
[g]Runner cultivar.

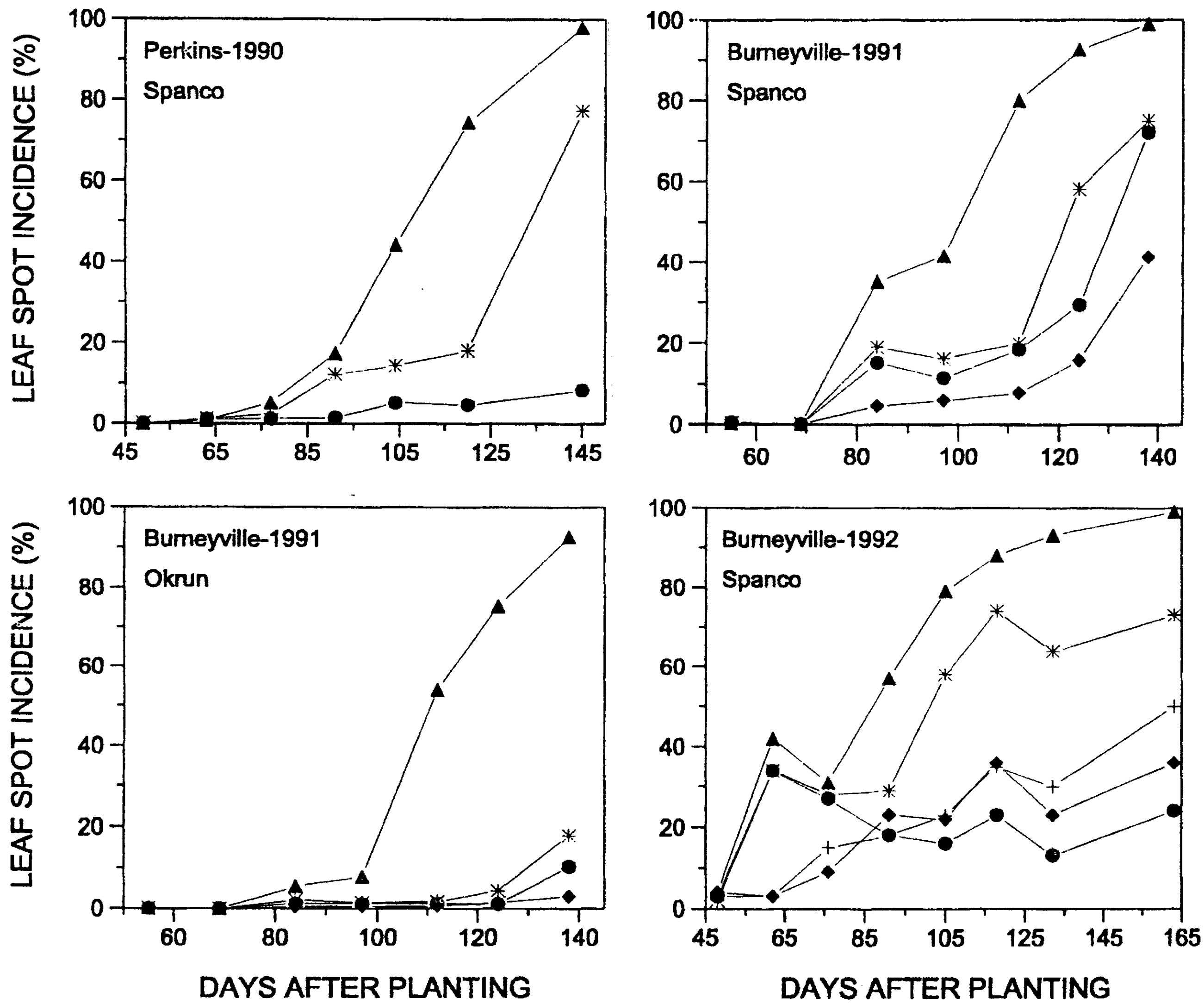

Fig. 1. Effects of spray program and fungicide on progress of early leaf spot on Spanco (spanish) and Okrun (runner) peanut cultivars in four irrigated trials. (▲) = control, (●) = 1.26 kg/ha chlorothalonil on a 14-d schedule; treatments applied according to the advisory program were (*) 1.26 kg/ha chlorothalonil, (◆) 0.14 kg/ha tebuconazole, and (+) 0.13 kg/ha propiconazole.

not for Okrun. Yields of Spanco for both spray programs using chlorothalonil and the advisory program with tebuconazole were less than the tebuconazole 14-d treatment, but averaged 35% more than the control. The correlation between AUDPC and yield of Okrun (r=-0.47) was less than for Spanco (r=-0.72) and yields of Okrun did not differ between treatments. Incidence of southern blight was low on both cultivars treated with chlorothalonil (1-4%) while none was observed on tebuconazole or control treatments. The incidence of limb rot on Okrun was also greater for chlorothalonil treatments (16-23%) than for tebuconazole treatments (2-5%) and the control (5%). However, the incidence of these diseases was not correlated with yield.

At Ft.Cobb-1991, all treatments were equally effective on Spanco in reducing leaf spot incidence, defoliation, and AUDPC (Table 3). Leaf spot incidence on Florunner was low and did not differ between treatments. Leaf spot did not influence yield of either cultivar. The incidence of Sclerotinia blight on Florunner was high in treated and untreated plots (57-78%) and reduced yields (r=-0.76). Sclerotinia blight on Spanco was lower in treated (9-15%) than in untreated (1%) plots, but was not correlated with yield. Southern blight on Spanco ranged from 2 to 4% in the control and chlorothalonil treatments, but was 1% or less in the tebuconazole treatments. One or two fewer sprays per season were made over the three sites in 1991 with the advisory compared to the 14-d program (Table 3).

Where fungicides were compared using the advisory program at Burneyville-1992, leaf spot control and yield were affected by fungicide (Table 4). Leaf spot incidence, defoliation, and AUDPC were greater on both cultivars for advisory than 14-d chlorothalonil programs. Advisory treatments of propiconazole and tebuconazole provided better leaf spot control on both cultivars than the advisory treatment of chlorothalonil. AUDPC values for the SBI fungicides were similar to the 14-d treatment of chlorothalonil. Leaf spot increased on Spanco to the same

Table 3. Effects of spray program and fungicide on control of early leaf spot in irrigated spanish and runner cultivars of peanut at Burneyville (BU), Wetumka (WE), and Ft. Cobb (FC), OK in 1991.

Treatment and rate	Spray program	Spray			Leaf spot incidence[a]			Defoliation[b]			AUDPC[c]			Yield		
		BU	WE	FC	BU	WE	FC	BU	WE	FC	BU	WE	FC	BU	WE	FC
kg/ha		---------no.--------			--------------------%--------------------									------------kg/ha-----------		
Spanish cultivars[d]																
Chlorothalonil 1.26	14-d	5	6	6	72	9	1	34	2	0	1514	404	36	3102	4008	3925
Chlorothalonil 1.26	Advisory	4	5	4	75	18	1	37	3	0	2054	768	62	2831	4048	3865
Tebuconazole 0.14[e]	14-d		6	6		5	1		0	0		250	36		4850	3784
Tebuconazole 0.14[e]	Advisory	4	5	4	41	29	2	17	12	0	751	1402	62	3119	4191	4069
Control	-	0	0	0	99	89	77	92	76	49	4057	3233	1022	2068	2991	3438
LSD[f]					11	7	4	8	-	-	331	335	150	527	603	ns
Runner cultivars[g]																
Chlorothalonil 1.26	14-d	6	7	6	10	2	2	0	0	0	136	86	111	5001	5969	2583
Chlorothalonil 1.26	Advisory	5	5	4	18	3	4	1	0	0	256	166	136	4780	5379	2156
Tebuconazole 0.14[e]	14-d		7			2			0			143			6115	
Tebuconazole 0.14[e]	Advisory	5	5	4	3	5	7	0	0	0	61	477	182	5170	5879	3011
Control	-	0	0	0	92	90	2	63	73	0	2538	2941	117	3780	5004	2767
LSD					6	6	ns	-	-	-	228	397	110	395	ns	769

[a]Final estimations of percent symptomatic and defoliated leaflets.
[b]Final estimations of percent defoliated leaflets.
[c]Area under the disease progress curve.
[d]The spanish cultivar was Spanco at all locations.
[e]Spreader-sticker (Penetrator) added at 0.25% of spray solution.
[f]Fisher's least significant difference at $P \leq 0.05$, ns = no significant difference, - = not analyzed because one or more means had no variance.
[g]The runner cultivars were Okrun at Burneyville (BU) and Wetumka (WE) and Florunner at Ft. Cobb (FC).

level as the control following the first application of chlorothalonil (48 DAP), but did not increase with tebuconazole or propiconazole (Fig. 1). Tank-mix treatments of either benomyl or thiophanate-methyl and mancozeb resulted in AUDPC values similar to the chlorothalonil advisory treatment, but final disease incidence and defoliation were higher (Table 4). AUDPC and yield were correlated for both Spanco (r=-0.74) and Okrun (r=-0.89). Benomyl plus mancozeb on Spanco and Okrun, and thiophanate-methyl plus mancozeb on Okrun were the only treatments that resulted in yields that were reduced below the chlorothalonil 14-d treatment. One and two fewer sprays to Spanco and Okrun, respectively, were applied with the advisory compared to the 14-d program.

Discussion

The simplified PSC advisory for scheduling fungicide sprays to manage early leaf spot was effective in maintaining peanut yields in a reduced spray program over 3 yr and under the range of production systems in Oklahoma. In comparing spray programs with chlorothalonil, the most widely used leafspot fungicide, there were never any differences in yield between the advisory and 14-d programs. Yields averaged 3015, 3003, and 2303 kg/ha for spanish cultivars (n=8) and 4108, 3855, and 3066 kg/ha for runner cultivars (n=6) with the 14-d schedule, advisory program, and control, respectively. These results support previous conclusions from studies with nonirrigated, virginia cultivars (5,15,20). Reductions in the number of sprays per season with the advisory program averaged 1.7 and 2.0 for spanish and runner cultivars, respectively. It is possible that the number of sprays could have been further reduced by using the advisory to schedule the first spray (5).

All but two of the trials in this study were conducted in irrigated fields. While irrigation has been shown to increase leaf spot incidence (21), the advisory program was effective in this study in irrigated trials where T and RH were recorded either under the influence of irrigation (Perkins-1990, Calera-1991, Ft. Cobb-1991, and Wetumka-1991) or not (Calera-1990 and Burneyville-1991 and 1992). This may be attributed to irrigation events occurring primarily during dry periods resulting in brief occurrences of RH≥95%. At Perkins-1990 and Ft. Cobb-1991, dataloggers were deployed which recorded precipitation in addition to T and RH. At Perkins-1990 where plots were irrigated during the day, the duration of RH≥95% within 48 hr of an event (≥2.54 mm) averaged 3.1 and 10.8 hr following irrigation and rain, respectively. At Ft. Cobb-1991 where plots were irrigated both day and night, the duration of RH≥ 95% averaged 2.6 and 11.0 hr following irrigation and rain events, respectively. These observations support the hypothesis that irrigation may not always provide sufficient wetness periods for conidial germination and host penetration.

Applications of chlorothalonil according to the advisory program resulted in a higher incidence of leaf spot than the 14-d schedule which agrees with previous reports (5,15,20). Final leaf spot incidence in this study averaged 15% and 34% on spanish cultivars and 5% and 14% on runner cultivars for the 14-d and advisory programs, respectively. The previous cropping of peanuts at most sites in this study may have contributed to the high levels of leaf spot in some treatments. Crop rotation is known to reduce primary inoculum and delay the onset of leaf spot (14). Unfortunately,

Table 4. Effects of spray program and fungicide on control of early leaf spot of peanut on the spanish cultivar Spanco (SP) and the runner cultivar Okrun (OK) at Burneyville, OK in 1992.

Treatment and rate	Spray program	Spray		Leafspot incidence[a]		Defoliation[b]		AUDPC[c]		Yield	
		SP	OK	SP	OK	SP	OK	SP	OK	SP	OK
kg/ha		---- no. ----		---- % ----						--- kg/ha ---	
Chlorothalonil 1.26	14-d	6	7	24	4	6	0	2018	258	4221	4340
Chlorothalonil 1.26	Advisory	5	5	73	24	43	5	4433	1164	4001	4001
Propiconazole 0.13	Advisory	5	5	50	7	21	0	2070	234	4018	4289
Tebuconazole 0.14[d]	Advisory	5	5	36	4	14	0	1887	180	4085	4594
Benomyl 0.28 + mancozeb 1.68[d]	Advisory	5	5	85	43	53	12	3905	1157	3729	3306
Thiophanate-methyl 0.38 + mancozeb 1.68[d]	Advisory	5	5	91	49	61	18	4298	1262	3746	3153
Control	-	0	0	99	81	90	44	6052	3109	2255	1882
LSD[e]				11	10	11		558	359	487	675

[a]Final estimations of percent symptomatic and defoliated leaflets.
[b]Final estimations of percent defoliated leaflets.
[c]Area under the disease progress curve.
[d]Spreader-sticker (Penetrator) added at 0.25% of spray solution.
[e]Fisher's least significant difference at $P \leq 0.05$, ns = no significant difference, - = not analyzed because one or more means had no variance.

the lack of this practice in much of Oklahoma has led to increases in several diseases in addition to leaf spot. The height at which T and RH were measured differed from some previous studies and may have affected advisory performance. Jenson and Boyle (10,11) measured T and RH near ground level between peanut rows. The same height is used in North Carolina in implementation of the PSC advisory (J. E. Bailey, personal communication). The height of 1.2 m in this study is closer to standard height of weather shelters (1.5 m) which may underestimate the duration of RH$\geq$ 95% at the plant canopy. This height was chosen both for convenience and because a goal was to measure ambient weather rather than microclimate. While we have not measured RH at different heights in Oklahoma, our experience has been that seasonal weather patterns impacting large areas greatly influence leaf spot incidence and resulting damage in a given year. We also assumed that ambient weather measurements would be more useful in disease forecasting over areas larger than a single field.

Differences between the reactions of spanish and runner cultivars to leaf spot were evident in this study and affected advisory performance. At the four sites where runner and spanish cultivars were planted in adjacent trials, runner cultivars had a lower incidence of leaf spot, less defoliation, and lower AUDPC's (Tables 3 and 4). Leaf spot increase in runner cultivars was often delayed by 2 wk or more (Fig. 1). The spanish and runner cultivars were separated to facilitate harvest at their different maturity dates. Other production practices were the same except that spray programs were maintained for a longer period on the later-maturing runner cultivars. These observations suggest that runners possess partial resistance to early leaf spot. A previous study with detached leaves also provided evidence for partial resistance in Florunner (8), but no differences in final disease incidence were observed between some spanish cultivars and Florunner in the field (16). In comparisons of leaf spot infection components for cultivars at single dates in the field, the Spanish cultivar Starr was more susceptible for some evaluation criteria, but not others (9). Results from this study (Tables 3 and 4) demonstrated the importance of measuring disease incidence over time when comparing cultivars.

The partial resistance of the runner cultivars to early leaf spot facilitated disease control with fungicides applied according to the advisory program. This could be important in grower acceptance of leaf spot advisories in Oklahoma. Leaf spot incidence and defoliation approached 75% and 50%, respectively, on spanish cultivars using the advisory in some instances. While yield was not affected, these levels of disease approached damaging levels and would alarm growers. Modification of the spray threshold appears warranted for spanish cultivars. In modifying the PSC advisory for use on cultivars with partial resistance, daily infection indices have been reduced by a factor appropriate for the level of resistance, thus indirectly increasing the spray threshold (15). A similar approach could be used to increase daily infection indices by a factor appropriate for the leaf spot reaction of spanish cultivars. The new advisory program developed for early leaf spot in Virginia is reported to provide better control than the PSC advisory (5). This model could be easily adapted to cultivars differing in leaf spot reaction.

Differences in fungicide performance with the advisory program were most evident on spanish cultivars. The SBI fungicides provided better control of leaf spot than chlorothalonil treatments on the cultivar Spanco in all trials except at Wetumka-1991. The second advisory spray (77 DAP) in this trial was made when foliage was wet and just before a heavy rain event. Leaf spot incidence increased 18 d later from about 5 to 30% in the tebuconazole-treated plots, but increased to only 9% in the chlorothalonil-treated plots. Chlorothalonil is relatively rain-fast and is recommended for chemigation in Oklahoma (24). The better overall performance of the SBI fungicides was likely due to their systemic nature and post-infection activity which was observed at Burneyville in 1991 where the first application was apparently made after an infection period had occurred (Fig. 1). The weather station there was set up on the first spray date, thus it did not provide an indication of the duration of post-infection activity of these fungicides. SBI fungicides should prove to be useful tools for leaf spot control in conjunction with weather-based advisories. The use of fungicide treatments less effective than chlorothalonil with the advisory program, such as the tank mixes tested at Burneyville-1992, does not appear warranted.

This study demonstrated the utility a leaf spot advisory program in Oklahoma, and identified a need for a more conservative spray threshold for spanish cultivars. Spray advisories were relatively simple to calculate with both hygrothermographs and dataloggers. Both types of weather monitoring equipment were reliable, but hygrothermographs required more maintenance and closer attention to RH calibration. An automated system for collection and interpretation of weather data and delivery of advisories will be required before broad implementation is possible. The Oklahoma MESONET, a network of automated, computer-linked weather stations will be operational in 1994 with at least one station per county. This system has the capability to deliver weather-based pest advisories to a large number of growers in the state. Field studies to compare different advisory systems and various thresholds for fungicide application have been initiated. Delivery of leaf spot advisories to growers in Oklahoma has the potential to reduce production costs for growers who intensively manage the disease, and increase the level of disease control for growers who fail to apply fungicides during critical periods of heavy infection.

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