Calendar-based and AU-Pnuts advisory programs with pyraclostrobin and chlorothalonil for the control of early leaf spot and stem rot on peanut[1]

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ABSTRACT

Efficacy of pyraclostrobin (two applications at 0.16 or 0.27 kg ai/ha) was evaluated in 2-, 3-, and 4-wk treatment programs with chlorothalonil for the control of early leaf spot and stem rot on the peanut cultivars Andru II, Carver, DP-1 in 2003 and the former two cultivars along with C-99R in 2004 and 2005. Applications were also scheduled using the AU-Pnuts leaf spot advisory in 2004 and 2005. In order to target both early leaf spot and stem rot, the two applications of pyraclostrobin, which were included in each calendar treatment schedule, were made approximately 60 and 90 days after planting. Chlorothalonil at 1.26 kg ai/ha filled the remaining application slots in the above treatment schedules. A 2-wk calendar chlorothalonil program was included as a control. A total of seven-, five-, and four-total fungicide applications were scheduled according to the 2-, 3-, and 4-wk calendar schedules, while six fungicide applications were triggered in each year by AU-Pnuts. Cultivar × treatment interactions for early leaf spot, stem rot, and yield were not consistent across years; data were pooled across cultivars for analyses of fungicidal program effects. Single degree of freedom contrast analyses indicated that pyraclostrobin as part of a 2-wk fungicide programs provided better early leaf spot control in 2 of 3 study years compared to the chlorothalonil-only program. Yields tended to be higher with the pyraclostrobin/chlorothalonil programs than with chlorothalonil-alone. Application interval and pyraclostrobin concentration each had a significant impact on early leaf spot control. Pyraclostrobin at 0.27 kg ai/ha controlled early leaf spot better than the 0.16 kg ai/ha rate, and some yield increase was also observed. When pyraclostrobin was applied as part of the 2-wk interval programs, leaf spot control was better in two of three years than as part of the 3-wk interval programs, and consistently better than when part of the 4-wk interval programs. Incidence of stem rot was not influenced by pyraclostrobin rate or treatment interval. Yield response with pyraclostrobin/chlorothalonil programs was consistently influenced by application interval, with the 2-wk intervals providing higher yield in two of three years compared to 3-wk application intervals. Yield for the 2-wk and AU-Pnuts advisory pyraclostrobin/chlorothalonil programs was also similar in one of two trials.

Key Words: Expert system, Headline 2.09E, strobilurin fungicide, Bravo Ultrex, *Cercospora arachidicola*, *Sclerotium rolfsii*, *Arachis hypogaea*.

Pyraclostrobin is a broad-spectrum strobilurin fungicide that has demonstrated translaminar movement through the leaf epidermis and mesophyll layers but is not redistributed like a true systemic fungicide 1,2,23. In previous trials, the level of control of early leaf spot, caused by the fungus *Cercospora arachidicola* Hori, and late leaf spot, caused by the fungus *Cercosporidium personatum* (Berk. & Curtis) Deighton, on peanut (*Arachis hypogaea* L.) obtained with 3 or more pyraclostrobin applications as part of a recommended seven-application calendar program was often superior to that provided by other fungicides 9,13. Hagan *et al* 14 noted that a 2-wk calendar program that included three or four applications of pyraclostrobin controlled stem rot, caused by the fungus *Sclerotium roflsii* Sacc., as effectively as recommended tebuconazole, azoxystrobin, and flutolanil + chlorothalonil programs. Due to exceptional residual activity, pyraclostrobin applied at rates of 0.16 to 0.27 kg ai/ha is labeled for early and late leaf spot control at treatment intervals up to 3-wk compared to the 2-wk interval recommended for other fungicides 18. At extended application intervals, multiple pyraclostrobin application programs have proven as effective in controlling early leaf spot as recommended 2-wk chlorothalonil, tebuconazole, and azoxystrobin programs 9,13. However, to comply with Fungicide Resistance Action Committee (FRAC) guidelines for strobilurin fungicides, no more than two applications of pyraclostrobin as part of a 7-application program may be made to a given peanut field per production season (www.frac.info/frac/index.htm).

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Recommended seven-application calendar-based leaf spot and stem rot control programs may account for more than 25% of the variable cost in the 2006 Alabama peanut production budget (http://www.ag.auburn.edu/agec//pubs/budgets/2006/RowCrops/pnut2006plan.pdf). Due to decreasing profitability of peanut production, emphasis on lowering production costs by reducing fungicide inputs has increased. The recent release of peanut cultivars with partial resistance to early and/or late leaf spot 7,10,11,12, as well as the registration of the highly efficacious fungicide pyraclostrobin 20,23, may allow treatment intervals to be extended from approximately 2- to 3- or possibly 4-wk intervals without jeopardizing disease control or yield. However, a significant increase in late leaf spot severity was previously seen on the partially disease resistant cultivar Southern Runner when the application interval with chlorothalonil at 1.26 kg ai/ha was extended from 2- to 3-wk 6. In addition, a sizable yield reduction was associated with increased disease severity on partially leaf spot resistant peanut cultivars in one out of three years with the extended 3-wk treatment interval 3,6. Monfort *et al* 19 also noted greater early leaf spot damage on partially leaf spot resistant cultivars treated at extended intervals, but yield for the recommended and extended calendar programs for tebuconazole and azoxystrobin, but not chlorothalonil, were similar. In addition, Cantonwine *et al* 8 reported early leaf spot intensification when application intervals with chlorothalonil were lengthened from 2- to 4-wk, yet yield response did not significantly differ among the 2-, 3-, and 4-wk treatment schedules in 2002 or among the 3- and 4-wk treatment schedules in 2003.

The AU-Pnuts leaf spot advisory was designed to optimize fungicide application timing when weather patterns are most conducive to the development of leaf spot diseases on peanut 17. According to this advisory, a fungicide application is triggered by the number of accumulated rain or irrigation events $>$ 2.5 mm [0.10 inch] within a 24 hr period and the 5-d average rainfall forecast. When peanut seedlings first emerge, the counting of rain events for the first fungicide application begins. Regardless of the 5-d average rainfall forecast, the first fungicide application is made no later than the sixth rain event. Beginning 10 d after the first and each subsequent fungicide application, a) three rain events, b) the 5-d average rainfall forecast is $\geq$ 50%, or c) a combination of one or two rain events and the 5-d average rainfall forecast triggers an application 17. Reductions of 1.25 and 2.5 fungicide applications per season on the leaf spot susceptible peanut cultivar Florunner 17 and partially leaf spot resistant cultivar Southern Runner 16 were obtained with the AU-Pnuts leaf spot advisory, respectively. Compared with the recommended 2-wk calendar leaf spot treatment schedule, Brenneman and Culbreath 6 saved two fungicide applications in two of three years with the AU-Pnuts advisory. Similar reductions in numbers of fungicide applications, noted with an AU-Pnuts azoxystrobin/chlorothalonil program by Bowen *et al* 3, were accompanied with an increased risk of damaging early leaf spot outbreaks and subsequent yield loss. In this study we evaluated the impact of 2-, 3, and 4-wk calendar treatment schedules and the AU-Pnuts advisory on the effectiveness of selected rates of pyraclostrobin for control of early leaf spot and stem rot on susceptible and partially resistant peanut cultivars and on their yields.

Materials and Methods

Production Methods

Peanut (*Arachis hypogaea* L.) cultivars were planted in a Dothan fine sandy loam [fine, loamy, siliceous, themic Plinthis Palendut] with less than 1% organic matter on 16 May 2003, 25 May 2004, and 18 May 2005 at a rate of 17 seed/m of row in an irrigated field at the Wiregrass Res. And Ext. Center, Headland, AL. Runner peanut cultivars Andru II, which matures 126 to 140 d after planting (DAP) (maturity group 3) and Carver which matures 130 to 145 DAP (maturity group 4) were included in all three years. The cultivar DP-1, which matures 140 to 165 DAP (maturity group 5), was planted in 2003 but was replaced with the maturity group 5 cultivar C-99R in 2004 and 2005. Both DP-1 and C-99R have partial resistance to leaf spot diseases and stem rot 7,11,12, while Andru II and Carver are susceptible to these diseases 12,19. In late March, the plot areas, which were maintained in a peanut–cotton–peanut rotation, were turned with a moldboard plow, and then prepared for planting with a disk harrow. Optimum soil fertility and pH were maintained according to the results of a soil fertility assay conducted by the Soil Testing Lab. at Auburn Univ. 15. In all three trials, the insecticide aldicarb [Temik 15G, Bayer Crop Protection, Kansas City, MO] at 1.1 kg ai/ha was applied in-furrow to control thrips. In 2003 and 2004, 0.85 kg ai/ha endosulfan [Sonolan HFP, Dow AgroSciences, Indianapolis, IN] + 0.026 kg ai/ha of diclosulam [Strongarm, Dow AgroSciences, Indianapolis, IN] were broadcast in mid-April for pre-emergent weed control. In 2005, a May 16 broadcast application of 0.85 kg ai/ha

Table 1. Fungicide application dates expressed as days after planting for the calendar and AU-Pnuts advisory treatments in 2003, 2004, and 2005.

Program	Days after planting[z]		
	2003	2004	2005
2-wk			
Chlorothalonil	31, 45, 61, 75, 89, 103, 117	28, 44, 57, 70, 84, 99, 113	36, 51, 65, 77, 90, 105, 118
2-wk			
Chlorothalonil	31, 45, 75, 103, 117	28, 44, 70, 99, 113	36, 51,77, 105, 118
Pyraclostrobin[y]	61, 89	57, 84	65, 90
3-wk			
Chlorothalonil	31, 73, 117	28, 70, 113	36, 78, 118
Pyraclostrobin	52, 84	50, 92	58, 100
4-wk			
Chlorothalonil	31, 117	28, 113	36,118
Pyraclostrobin	59, 78	57, 84	65, 90
AU-Pnuts[w]			
Chlorothalonil	—	28, 44, 78, 113	26, 44, 79, 106
Pyraclostrobin		61, 97	57, 89

[z]Planting dates were 16 May 2003, 25 May 2004, and 18 May 2005.
[y]Date of an application for either 0.16 or 0.27 kg ai/ha rate of pyraclostrobin.
[w]Applications are triggered on the basis of the number of accumulated rain events, each with > 2.5 mm of rain or irrigation within a 24-hr period, and the 5-day average rainfall forecast.

endosulfan + 0.026 kg ai/ha of diclosulam was followed by a post-emergent broadcast application of 0.92 kg ai/ha pendimethalin [Prowl 3.3, BASF, Research Triangle, NC] on 26 May. In 2003, post-emergent grass control was obtained with broadcast applications of 0.14 kg ai/ha of clethodim [Select, Agriliance LLC, St. Paul, MN] + 1.1 L/ha of Prime Oil [Agriliance LLC, St. Paul, MN] on 23 June and 10 July. The herbicides imizapic [Cadre, BASF, Research Triangle, NC] at 0.05 kg ai/ha, bentazone at 0.37 kg ai/ha, and aciflurofen [Storm, United Phosphorus Inc., Trenton, NJ] at 0.18 kg ai/ha were broadcast on 15 July 2005. In addition, escape weeds were pulled by hand or killed by cultivating the row middles with flat sweeps. Due to frequent summer rain events in 2003, the test area was not irrigated. In 2004, 2.8 cm/ha of water was applied on 30 July and 17 August. In the following year, plots received 1.7 and 2.5 cm/ha water on 1 August and 13 September, respectively. A split plot design with peanut cultivars as whole plots and fungicide treatments as subplots was used. Whole plots were randomized in four complete blocks. Individual subplots, which consisted of four 9.2-m rows spaced 0.9-m apart, were arranged in four replications.

Fungicide Programs

In 2003, 2004 and 2005, applications of 0.16 and 0.27 kg ai/ha of pyraclostrobin [Headline 2.09E, BASF, Research Triangle, NC] were incorporated into treatment programs with seven, five, and four total fungicide applications with 2-, 3-, and 4-wk intervals, respectively, as well as AU-Pnuts advisory treatment schedules in 2004 and 2005. For all pyraclostrobin/chlorothalonil programs, applications of this fungicide were made approximately 60 and 90 days after planting. Applications of chlorothalonil [Bravo Ultrex, Syngenta Crop Protection, Greensboro, NC] at 1.26 kg ai/ha filled the remaining treatment slots in the pyraclostrobin programs. In addition, a seven application (2-wk calendar) program with chlorothalonil at 1.26 kg ai/ha was included as a control. Six total fungicide applications were triggered by the AU-Pnuts advisory in both 2004 and 2005. Fungicide application dates for the calendar and advisory treatment schedules are listed in Table 1. Treatments were made with a tractor mounted boom sprayer with three TeeJet® TX-8 [Spraying Systems Co., Wheaton, IL] nozzles per row calibrated to deliver 140 L/ha of spray volume.

Disease Assessment and Statistical Analysis

Early and late leaf spot were rated together using the 1 to 10 Florida peanut leaf spot scoring system where 1 = no disease, 2 = very few leaf spots on leaves in lower canopy, 3 = few lesions on leaves in lower and upper canopy, 4 = some leaf spots on leaves in lower and upper canopy with ≤10% defoliation, 5 = leaf spots noticeable in upper canopy and ≤25% defoliation, 6 = leaf spots

Table 2. Ratings for early leaf spot and stem rot, and yield of peanut cultivars evaluated at the Wiregrass Research and Extension Center, Headland, AL.

		Early Leaf Spot[z]			Stem Rot[y]			Yield kg/ha		
Peanut Cultivar	Maturity	2003	2004	2005	2003	2004	2005	2003	2004	2005
Andru II	Early	4.2 b[w]	4.0 a	3.9 b	9.4 b	11.7 b	9.2 b	3990 b	3802 b	3498 a
Carver	Mid	4.4 ab	3.9 a	4.0 b	10.9 b	14.0 ab	15.4 a	4327 a	4082 a	3112 b
DP-1	Late	4.6 a	-	-	14.4 a	-	-	3584 c	-	-
C-99R	Late	-	3.8 a	4.8 a	-	15.4 a	16.2 a	-	4221 a	3706 a

[z]Early leaf spot was rated using the Florida 1 to 10 leaf spot scoring system.
[y]Stem rot incidence is expressed as the number of disease loci per 30 m of row.
[w]Means followed by the same letter are not significantly different Fisher's protected least significant difference (LSD) test (P = 0.05).

numerous with ≤50% defoliation, 7 = leaf spots numerous with ≤75% defoliation, 8 = numerous leaf spots on leaves with ≤90% defoliation, 9 = few remaining leaves covered with leaf spots with ≤95% defoliation, and 10 = plants 100% defoliated or dead 10. Final leaf spot ratings for the 2003 trial were recorded on 17 September, 25 September, and 6 October for Andru II, Carver, and DP-1, respectively. For the 2004 trial, early leaf spot severity was rated on Andru II on 21 September, for Carver on 1 October, and for C-99R on 13 October. In 2005, early leaf spot ratings were logged on 19 September for Andru II, on 27 September for Carver, and on 12 October for Florida C-99R. The pod maturity hull scrape method was used to estimate the optimal inverting date for each cultivar 24. In 2003, plots were inverted with a 2-row digger/inverter on 19 September for Andru II, 29 September for Carver, and 14 October for DP-1. Andru II, Carver, and C-99R were inverted on 23 September, 7 October, and 22 October 2004 and on 20 September, 3 October, and 17 October 2005, respectively. Stem rot incidence, which is described as the number of disease loci where 1 locus is defined as ≤ 30.5 cm of consecutively damaged plants per row, was determined from the two center rows of each subplot immediately after inversion 21. Yields, which were taken from the two center rows of each four row plot, are reported at 10% moisture.

Fungicide program and cultivar effects on early leaf spot, stem rot, and yield in each trial were tested by analysis of variance and means were compared with Fisher's protected least significant difference (LSD) 22. Single degree of freedom contrast analyses were done for comparing particular fungicide programs, especially the standard 2-wk chlorothalonil-only program to the programs that included pyraclostrobin. Using data only from those programs with pyraclostrobin, factorial analysis was done to determine differences due to intervals of application or concentration of the pyraclostrobin. The significance level used for all tests was initially set at P = 0.05. Correlation coefficients were calculated between yield and final early leaf spot rating and stem rot loci. When yield was significantly (P = 0.05) correlated to a disease variable, the disease variable was regressed on yield to determine that relationship.

Results

Rainfall

During the 2003 trial, rainfall totals for the months of May through September were at or above the historical average. Monthly rainfall totals for 2004 were equal to or higher than average for May, June, and September and below average for July and August. In 2005, monthly rainfall totals were equal to or higher than the historical average for the months of June, July, and August but were below to well below average for May, September, and October.

Early Leaf Spot

Early leaf spot was the predominant foliar disease throughout all study years, and final leaf spot ratings were generally similar among years (Table 2). The two-way interaction of cultivar × fungicide program was significant in 2003 and in 2005, likely due to anomalies in disease occurrence in a few plots. Specifically, in 2003, mean disease on DP-1 was significantly higher than on Carver or Andru II in the program including pyraclostrobin at 0.16 kg ai/ha applied on 3-wk intervals (5.5 vs. 4.0 and 4.2, respectively). Similarly, in 2005, disease on C-99R was higher than on the other cultivars in the program with pyraclostrobin at 0.27 kg ai/ha applied on 2-wk intervals (4.5 vs. 3.1 and 3.5, respectively). Only the main effects of cultivar and fungicide program were considered further.

Final early leaf spot ratings were significant due to cultivar in 2003 and 2005, and were lower on Andru II than on DP-1 or on C-99R, respectively

Table 3. Disease ratings and yields from fungicide programs evaluated in southeast Alabama.

	Early Leaf Spot[y]			Stem Rot[x]			Yield kg/ha		
Fungicide Program[z]	2003	2004	2005	2003	2004	2005	2003	2004	2005
Chlorothalonil-only, 2-wk	4.8	4.0	4.2	10.2	13.9	11.2	3928	4011	3486
Pyraclostrobin Rate									
With pyraclostrobin at 0.16 kg a.i.	4.6 a[w]	4.0 a	4.3 a	12.6 a	13.8 a	14.1 a	3911 b	4076 a	3467 a
With pyraclostrobin at 0.27 kg a.i.	4.0 b*	3.8 b	4.1 a	11.0 a	13.3 a	12.6 a	4208 a	4154 a	3495 a
Spray Interval									
2-wk program	3.6 c*	3.4 c*	4.0 b	11.3 a	12.8 a	11.8 b	4217 a	4316 a	3789 a
3-wk program	4.2 b*	4.1 a	3.6 b*	11.8 a	13.9 a	18.3 a*	4338 a*	3987 bc	3322 b
4-wk program	5.1 a	4.3 a*	4.8 a*	12.0 a	14.9 a	12.1 b	3622 b	3935 c	3446 ab
AU-Pnuts program	Nd[v]	3.7 b	4.6 a	Nd	12.8 a	11.3 b	Nd	4222 ab	3373 b

[z]Fungicide programs other than the chlorothalonil-alone program (applied at 1.26 kg a.i./ha at 2-wk intervals), included two pyraclostrobin applications instead of chlorothalonil as close to 60 and 90 days after planting as allowed with stated intervals.

[y]Early leaf spot was rated using the Florida 1 to 10 leaf spot scoring system.

[x]Stem rot incidence is expressed as the number of disease loci per 30 m of row.

[w]Means followed by the same letter, within a column under the ''Pyraclostrobin rates'' or ''Spray intervals'' heading, are not significantly different according to Fisher's protected least significant difference test (P = 0.05).

[v]Nd = treatment not included in 2003 trial.

Asterisks indicate significant difference of pyraclostrobin/chlorothalonil program from the chlorothalonil-alone program as determined by single degree of contrast analyses (P = 0.05).

(Table 2). Early leaf spot on Andru II and Carver was less than on the late maturing cultivar C-99R in 2005 (Table 2).

Single degree of freedom contrast analyses showed that the standard 2-wk calendar chlorothalonil-alone program was significantly less effective against early leaf spot than the either of the 2-wk pyraclostrobin/chlorothalonil programs in two of three years of the study (Table 3). In two of three years, the 3-wk interval pyraclostrobin/chlorothalonil program also provided better leaf spot control than the 2-wk calendar chlorothalonil-alone program. Factorial analysis of the pyraclostrobin/chlorothalonil programs indicated no significant effect due to the two-way interaction of fungicide concentration × application interval in any study year. Final leaf spot ratings in 2003 and 2004 were significantly lower with the 0.27 kg ai/ha concentration than with the 0.16 kg ai/ha concentration of pyraclostrobin (Table 3). Application interval also had a significant effect on early leaf spot levels in each year, and the 2-wk interval provided better control than the 4-wk interval in all three years (Table 3). In 2003, the 3-wk pyraclostrobin/chlorothalonil program resulted in greater disease than the 2-wk program, but had lower disease ratings than with 4-wk treatment. In 2004 and 2005, the 2-wk programs consistently allowed less disease than the 4-wk programs, and AU-Pnuts scheduling allowed early leaf spot levels that were intermediate to the 2-wk and 4-wk programs (Table 3).

Stem Rot

Incidence of stem rot was significantly affected by cultivar in all three years. In each year, the late maturing cultivars DP-1 and C-99R consistently had a higher incidence of stem rot than the early maturing cultivar Andru II (Table 2). Fungicide program significantly affected stem rot incidence in 2005 only, and there was no significant effect due to the two-way interaction of cultivar × fungicide program in any study year. Incidence of stem rot in plots treated with chlorothalonil-alone was similar to the ratings for the 2- and 3-wk pyraclostrobin/chlorothalonil programs (Table 3). One exception occurred in 2005, when plots treated at 3-wk intervals with pyraclostrobin/chlorothalonil had a higher incidence of stem rot than all other treatments; this was also reflected in contrast analysis showing that the 3-wk interval program with pyraclostrobin and chlorothalonil had higher stem rot loci counts than chlorothalonil-alone.

Yield

In 2003, cultivar and fungicide program, but not the two-way interaction of these effects, significantly affected yield. Carver was the highest yielding cultivar, and DP-1 yielded less than Andru II (Table 2). When applied at 2-wk intervals, the chlorothalonil-alone program provided yields that were similar to those from the program with 0.16 kg ai/ha pyraclostrobin, but lower than those from the 0.27 kg ai/ha pyraclostrobin/chlorothalonil program in 2003. In addition, the 3-wk pyraclostrobin/chlorothalonil programs had higher yields than the standard 2-wk chlorothalonil-only program (Table 3). Within pyraclostrobin/chlorothalonil programs, both concentration and application interval had significant effects on yield, but there was not a significant 2-way interaction. Yields were greater with the program with the higher compared to the lower application rate of pyraclostrobin, and with 2- or 3-wk application intervals compared to the 4-wk interval programs.

In 2004, C-99R yielded significantly more than Carver and Andru II (Table 2). Yield was also affected by the fungicide program and the 2-way cultivar × fungicide interaction. Significance of the two-way interaction was likely due to low yields with the 0.27 kg ai/ha pyraclostrobin program at 2-wk intervals with Andru II for which the mean yield was 3696 kg/ha. This yield contrasts to > 4150 kg/ha for the 2-wk pyraclostrobin/chlorothalonil programs with other cultivars. Yields also did not differ between plots treated with chlorothalonil-alone compared to any pyraclostrobin/chlorothalonil program (Table 3). Factorial analysis among pyraclostrobin/chlorothalonil programs indicated that only application interval affected yield, and greater yields were observed with pyraclostrobin applied at 2-wk intervals compared to 3- or 4-wk intervals; yield attained with AU-Pnuts advisory was similar to that with 2-wk application intervals (Table 3).

In 2005, cultivar, but not fungicide program, had a significant effect on yield, and a significant 2-way interaction was noted. Carver yielded less than C-99R or Andru II (Table 2). Contrast analysis indicated that yield response with chlorothalonil-alone did not differ from any of the pyraclostrobin/chlorothalonil programs (Table 3). Within pyraclostrobin/chlorothalonil programs, neither of the main effects nor the 2-way interaction was significant. As noted in previous years, the 2-wk application interval allowed higher yields than 3-wk interval and AU-Pnuts advisory programs. No differences in yield were noted for programs that included the 0.17 kg ai/ha and 0.26 kg ai/ha rates of pyraclostrobin (Table 3).

Correlation and regression analysis confirmed that leaf spot and stem rot significantly affected yield, though not consistently across years or all three cultivars. Yield of Andru II was not significantly affected by the final early leaf spot rating or to stem rot incidence in any study year. Yield of Carver, however, was reduced 5% ($P = 0.0004$) and 8% ($P = 0.0013$) for each unit of leaf spot severity in 2003 and 2004, respectively, and by 2% ($P = 0.0001$) in 2005 for each stem rot locus. Yields of DP-1 and C-99R were affected in each year by stem rot: DP-1 had 2% less yield per stem rot locus in 2003 ($P = 0.0016$), and C-99R had 1.3% ($P = 0.0001$) and 2% ($P = 0.0001$) lower yield per locus in 2004 and 2005, respectively.

Discussion

Portillo *et al* 20, Culbreath *et al* 9, and Hagan *et al* 13 have previously demonstrated that pyraclostrobin often controls early and late leaf spot on peanut better than most registered fungicides. While the application rates evaluated in these earlier studies were similar, the treatment programs included an additional one to five more applications than the two specified on the current pyraclostrobin federal label and in FRAC guidelines for strobilurin fungicides. In the current study, seven-spray fungicide programs that included two pyraclostrobin applications at 60 and 90 DAP consistently provided better control of early leaf spot than the standard 2-wk calendar chlorothalonil-alone program. As indicated by disease ratings that did not exceed 3.9 over the three year study period, symptoms on peanuts protected with the above pyraclostrobin/chlorothalonil programs were restricted to light leaf spotting in the lower and mid-canopy, as well as a very low level of premature defoliation. However, while leaf spot control obtained with the 2-wk programs that included pyraclostrobin was superior to that with chlorothalonil-alone, there was no consistent gain in yield with the pyraclostrobin/chlorothalonil programs.

Culbreath et al 9 noted that the difference in leaf spot control with the 0.17 and 0.22 kg ai/ha rates of pyraclostrobin was minimal. In our comparison of the 0.16 and 0.27 kg ai/ha rates, early leaf spot ratings were numerically lower in all three years with the higher concentration of pyraclostrobin. Yields also tended to be greater with the 0.27 kg ai/ha programs than with the 0.16 kg ai/ha pyraclostrobin, but this effect was significant only in one of three years.

As has been previously noted 13, efficacy of pyraclostrobin for the control of early leaf spot declined when application intervals were extended beyond the recommended 2-wk interval. Over both rates of pyraclostrobin, significantly better early leaf spot control was seen in two of three study years with the 2- rather than the 3-wk application intervals. However, the decline in early leaf spot control that was observed between the 2- and 3-wk pyraclostrobin/chlorothalonil programs only resulted in a minimal increase in the level of leaf spotting and defoliation. While disease increase was minimal, lower yields were seen in two of three study years, and regression analysis indicated that the difference in disease could result in 3 to 6% yield reduction.

The AU-Pnuts leaf spot advisory was designed to eliminate one or more fungicide applications without an appreciable decline in the control of leaf spot diseases or peanut yield 6,16,17. Bowen *et al* 3 recently noted similar control of early leaf spot and yield response in two of three years with the recommended 2-wk calendar and AU-Pnuts azoxystrobin/chlorothalonil programs along with a reduction of two to three fungicide applications with the standard AU-Pnuts advisory rules on the partially leaf spot resistant peanut cultivar C-99R. In the current study, AU-Pnuts scheduling allowed a savings of one fungicide application in each of the two years in which this was evaluated. When averaged across pyraclostrobin rates, the yield difference between the pyraclostrobin 2-wk and the AU-Pnuts schedules ranged from less than 100 kg/ha in 2004 to 400 kg/ha in 2005.

Two applications of pyraclostrobin at 0.16 or 0.27 kg ai/ha, as evaluated in this study, failed to reduce the incidence of stem rot when compared with chlorothalonil, a fungicide that is considered to have little if any activity against the causal fungus *S. rolfsii* 6. Differences in the level of stem rot control provided by pyraclostrobin in a previous study 13 may be related to application number. In the study by Hagan *et al* 13, plots treated with three applications of pyraclostrobin at 0.11 or 0.16 kg ai/ha had lower stem rot incidence compared to a standard 2-wk calendar chlorothalonil-alone program. In addition, the same three-application pyraclostrobin/chlorothalonil programs gave the same level of stem rot control as recommended azoxystrobin, flutolanil, and tebuconazole programs 13. However, in a concurrent Alabama study 14, a program that included three applications of pyraclostrobin at 0.11 kg ai/ha failed to reduce the incidence of this disease below that noted on peanut treated season-long with chlorothalonil alone; yield for these two treatments also were similar. Finally, stem rot control and yield response was far superior for chlorothalonil + flutolanil and azoxystrobin/chlorothalonil programs than for the above pyraclostrobin/chlorothalonil program 14. Overall, pyraclostrobin, even at the elevated label rate of 0.27 kg ai/ha, does not appear to be the optimum choice for preventing destructive stem rot outbreaks on peanut.

When applied according to label directions and FRAC guidelines, 2-wk calendar programs that included two applications of pyraclostrobin gave better control of early leaf spot than the standard 2-wk calendar chlorothalonil-alone program. In addition, the 3-wk pyraclostrobin/chlorothalonil programs for the control of early leaf spot and yield response were usually comparable to that obtained with the above chlorothalonil-only program. However, yield response with the 3-wk pyraclostrobin/chlorothalonil program fell below that of the 2-wk programs in 2004 and 2005 by 350 and 450 kg/ha, respectively. At current market prices, the yield difference between the 2- and 3-wk pyraclostrobin/chlorothalonil programs, after accounting for the cost of the two chlorothalonil applications saved with the 3-wk program, translates into a loss of $44 to $56/ha. Similar patterns of yield declines at extended application intervals with calendar and advisory schedules have previously been reported for chlorothalonil and tebuconazole on partially leaf spot resistant peanut cultivars 6. Higher leaf spot ratings and lower yields observed in this study suggests that the application interval for a fungicide program that includes two applications of pyraclostrobin should be more frequently than once every 4-wk where peanuts are cropped every second year or other situations where destructive disease outbreaks are expected. Performance of the AU-Pnuts pyraclostrobin/chlorothalonil treatments was intermediate between that of the 2- and 3-wk calendar treatments in 2004 and was equal to the 3-wk treatment in the following year.

Carver and Andru II peanuts are considered among the most susceptible runner peanut cultivars to leaf spot diseases 12,18. However, final early leaf spot ratings for these cultivars were similar to those recorded for DP-1 and C-99R in 2003 and 2004, respectively, and were lower than for C-99R in 2005. In previous studies conducted in Alabama 14 and Georgia 19, C-99R was significantly less susceptible to early leaf spot than Georgia Green 11. In addition, Cantonwine *et al* 7 noted that DP-1 was among the most early leaf spot resistant runner peanut cultivar. Differences between our results and those previously reported may be due to the period of time between the final fungicide application (between 9 and 14 September) and final rating dates, especially for the later maturing cultivars. DP-1 and C-99R were rated for early leaf spot 4-wks after the latest fungicide application, and disease would have increased during that time. Thus, this report is not seeking to refute previous findings about disease reactions of the cultivars. The early maturing (maturity group 3) cultivar Andru II typically had less stem rot damage than the later maturing Carver, DP-1, or C-99R. As previously noted by Hagan *et al* 12, Andru II may avoid stem rot by maturing before additional colonization of the pods and stems can occur. In contrast, late maturing (maturity group 5) cultivars, like DP-1 and C-99R, are exposed to attack by *S. rolfsii* for an additional 20 to 30 days beyond the optimum maturity date for Andru II. Incidence of stem rot on Carver was similar to levels noted on

C-99R in 2004 and 2005 but lower than those observed on DP-1. Lower stem rot damage levels for Andru II did not translate into higher yield. Yield for C-99R was significantly higher than for Carver in 2004 and 2005, and for Andru II in 2004. In the first year of this study, Carver significantly out-yielded both Andru II and DP-1.

In summary, extending fungicide application intervals may not be the best option for reducing production inputs, while maximizing peanut yield, particularly where cropping patterns or other production practices favor destructive outbreaks of leaf spot diseases and stem rot. The recently developed Georgia Fungal Risk Index, which quantifies the threat posed by leaf spot disease, stem rot, and TSWV on the basis of rotation pattern, cultivar selection, and management practices, is a tool that may allow peanut producers to customize fungicide programs field by field basis 4. Regardless, peanut producers need to carefully consider the increased risk of sizable yield losses against the cost savings from eliminating one or two fungicide applications before adopting an extended application program with any recommended fungicide on their peanut crop.

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