Calendar and AU-Pnuts Advisory Programs Compared for Leaf Spot Diseases and Rust Control on Peanut in Southwest Alabama

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Abstract
Peanut production acreage has increased substantially in southwest Alabama in the past several years. Since prevailing weather conditions in this newer production area are conducive to peanut diseases, primarily due to frequent rainfall during summer months, a 2-week calendar fungicide treatment schedule is considered essential to controlling leaf spot diseases and rust in order to optimize yields. In 2003, 2004, and 2005, extended calendar application intervals and the AU-Pnuts leaf spot advisory were compared with the recommended 2-week calendar schedule for peanut disease control on partially disease-resistant peanut cultivars (DP-1 in 2003 and Florida C99R in 2004 and 2005). Fungicide programs included recommended rates of azoxystrobin, chlorothalonil, and tebuconazole. Numbers of fungicide applications for the 2-, 3-, and 4-week calendar schedule treatments were 7, 5, and 4, respectively in each year. Fungicide applications made according to AU-Pnuts are based on rain events and resulted in 5 sprays in 2003 and 7 sprays in 2004 and 2005. Fungicide application schedule had a significant impact on leaf spots, rust, southern stem rot and yield in at least two of the three study years. Results indicate that recommendations for the 2-week fungicide application schedule should be maintained in this area. Fungicide program also had a consistent effect on measured variables, with the azoxystrobin program providing better disease control and higher yields.

Introduction
Over the past decade, peanut (Arachis hypogaea) production has expanded into southwest Alabama. This newer production area is approximately 200 mi west of the western edge of the historically important southeastern US peanut production region encompassing southeast Alabama, southwest Georgia, and northwest Florida. Southwest Alabama differs from peanut-production areas to the east in that it is warmer with greater rainfall (24). From May through September, average daily ambient temperature in southwest Alabama is 78.6°F, which is 1°F warmer than southeast Alabama. In addition, rainfall is an almost daily occurrence due to convection thundershowers.
In southwest Alabama, late leaf spot (caused by *Cercosporidium personatum*) is more common and damaging than early leaf spot (caused by *Cercospora arachidicola*), although both diseases are damaging (11). Rust (caused by *Puccinia arachidis*) is also a common disease found on peanut in southwest Alabama (Fig. 1), but is rarely found to the east. In contrast, southern stem rot (SSR; caused by *Sclerotium rofsii*) does not appear at as high incidence here as the disease does in Alabama's traditional peanut production counties (2), probably due to cropping history.

When not controlled, early and late leaf spot diseases can defoliate peanut and reduce anticipated yield by as much as 50% (27). Peanut rust can also contribute to plant defoliation and pod yield reduction. In the arid tropics and subtropics, rust-related yield losses have been found to be in excess of 50% when no fungicides have been applied to the peanut crop (29). With almost daily afternoon thunderstorms and the occasional tropical storm, an intensive fungicide program is considered essential to protecting peanut in southwest Alabama from damaging outbreaks of late leaf spot, early leaf spot, and rust in order to optimize pod yields. To effectively control these diseases, fungicide applications, which should be initiated 30 to 40 days after planting, must be repeated at 10- to 14-day intervals until 2 weeks before the anticipated digging date (30). Depending on rainfall patterns and cultivar selection, often eight fungicide applications are made to a peanut crop.

The recommended calendar fungicide program for controlling foliar, stem, and pod diseases can account for nearly 25% of the variable costs in a peanut production budget (1). With the availability of peanut cultivars with partial resistance to early and late leaf spot (3,7,10,12,13,14), reduction of fungicide inputs by lengthening application intervals may be an option for peanut producers. However, lengthening application intervals for chlorothalonil at 1.12 lb a.i./acre from 2- to 3-weeks on the partially late leaf spot-resistant peanut cultivar Southern Runner resulted in a significant increase in disease severity (4). In addition, a sizable reduction in yield was seen in one of three years on several partially leaf spot-resistant peanut cultivars when application intervals for chlorothalonil were extended from 2- to 3-weeks (4,13). Heavier leaf spot damage was noted on the peanut cultivars Florida C99R, MDR-98, and Georgia Green when they were treated at extended intervals, regardless of fungicide. However, yields were similar with 2- and 3-week application intervals when the fungicides used were tebuconazole or azoxystrobin (22).

The AU-Pnuts leaf spot advisory can be used for timing fungicide applications, and is an alternative to extending fungicide application intervals in order to reduce fungicide sprays. AU-Pnuts triggers a fungicide application based on the number of accumulated rain events, each with 0.10 inch of rain or irrigation within a 24-hour period, and the 5-day average rainfall forecast (18). Rain events are recorded for this advisory starting at true ground cracking when seedlings first emerge. Regardless of the 5-day average rainfall forecast, the first fungicide application must be made no later than the sixth rain event. Beginning 10 days after that, and for each subsequent fungicide application, additional applications are triggered: (a) after three rain events, (b) when the 5-day average rainfall forecast is $\geq 50\%$, or (c) when one or two rain events have been recorded and chance of rain in the 5-day forecast is $\geq 40\%$ or $\geq 20\%$, respectively (18). Studies with the susceptible cultivar Florunner demonstrated that an average of 1.25 applications of chlorothanil per year were saved with AU-Pnuts scheduling compared to 2-week application intervals (18). Thresholds for fungicide application were adjusted for the partially leaf spot-resistant cultivar Southern Runner, and up to 2.5 applications were saved (17). Brenneman and Culbreath (4) noted a reduction of two fungicide applications in two of three years.
using AU-Pnuts compared to the standard 2-week calendar schedule. A similar reduction in fungicide applications was observed with scheduling azoxystrobin applications using AU-Pnuts by Hagan et al. (12), but there was an increased risk of inadequate control of early leaf spot and yield loss. These previous studies with AU-Pnuts were conducted in southwest Georgia and southeast Alabama. The objective of this study was to compare the effectiveness of 2-, 3-, and 4-week calendar application schedules to the AU-Pnuts leaf spot advisory in the newer production area of southwest Alabama. The study also evaluates three fungicide programs that include azoxystrobin, tebuconazole, and chlorothalonil for control of leaf spots and rust. These studies were conducted using partially disease-resistant peanut cultivars.

**Production Methods**

Peanuts (*Arachis hypogaea* L.) were planted on 28 May 2003, 13 May 2004, and 12 May 2005 at the rate of 6 seed/ft of row in a field at the Gulf Coast Research and Extension Center, Fairhope, Baldwin County, AL. The late-maturing (maturity group 5) runner peanut cultivar DP-1, which was planted in 2003, was replaced with the late-maturing (maturity group 5) cultivar Florida C99R in 2004 and 2005. Both of these cultivars are partially resistant to early and late leaf spot, as well as southern stem rot (7,10,15). The test sites are maintained in a cotton-cotton-peanut rotation. The soil type is a Malbis fine sandy loam (fine-loamy, siliceous, thermic Plinthic Paleudults) with less than 1% organic matter.

The test site was prepared for planting with a disk harrow and ripper/hipper. Optimal soil fertility and pH were maintained according to the results of a soil fertility assay conducted by the Soil Testing Laboratory at Auburn University (16). Broadleaf and grass weeds were controlled by lightly incorporating a pre-emergence application of pendimethalin (Prowl 3.3, BASF, Research Triangle, NC) at 0.82 lb a.i./acre with a disk harrow. Newly emerged weeds were controlled with an application of paraquat (Gramoxone Maxx 3.0, Syngenta Crop Protection, Greensboro NC) at 0.11 lb a.i./acre of + bentazone at 0.33 lb a.i./acre + acifluorfen (Storm 4L, United Phosphorus Inc., Trenton, NJ) at 0.16 lb a.i./acre +Activate (Agriliance LLC, St. Paul, MN) non-ionic surfactant at 0.23 oz/gal of spray volume about 5 to 7 days after ground cracking. In 2005, 2,4 DB (Butyrac 200, Agri Star Inc., Ankey, IA) at 0.24 lb a.i./acre + paraquat 0.11 lb a.i./acre + a premix of bentazone (0.33 lb a.i./acre) + acifluorfen (0.16 lb a.i./acre) + Induce wetter/spread adjuvant (Helena Chemical Company, Collierville, TN) at 0.76 oz/gal of spray volume was applied. Sethoxydim (Poast Plus 1EC, BASF, Research Triangle, NC) at 0.17 lb a.i./acre + Prime Oil at 0.12 gal/acre was applied to control escape grass weeds on 25 June 2003. Imazapic (Cadre 70DG, BASF, Research Triangle, NC) at 0.06 lb a.i./acre + Activate surfactant at 0.20 oz/gal of spray volume was made on 11 July 2003 for broadleaf and nutsedge control. On 27 June 2005, imazapic at 0.04 lb a.i./acre + diclosulam (Strongarm 84WDG, Dow AgroSciences, Indianapolis, IN) at 0.14 lb a.i./acre at 0.3 oz/aacre + Induce wetter/spreader adjuvant at 0.8 oz/gal of spray volume was broadcast to control escaped broadleaf weeds. In addition, escape weeds were pulled by hand. Aldicarb (Temik 15G, Bayer CropScience, Kansas City, MO) at 1 lb a.i./acre was applied in-furrow at planting to control thrips. The test sites were not irrigated. Plots were inverted on 18 October 2003, 18 October 2004, and 10 October 2005. Windrows were combined 2 to 4 days later. Yields are reported at 10% moisture.

Normal cumulative rainfall for May through October in Fairhope, Alabama, is approximately 35.5 inches which is more than the 26.8-inch normal amount for southeast Alabama for the same months (24). In 2003 and 2005, actual rainfall was similar to the 30-year normal for Fairhope, but was 24% less than normal in 2004. In each of the three study years, average daily ambient temperatures for May through Oct were close to normal, averaging 75.8° to 77.5°F.
**Fungicide Treatments**

A randomized complete block design of 12 treatments with four replications was used. The treatment design consisted of factorial combinations of three fungicide programs (designated as chlorothalonil, tebuconazole, and azoxystrobin) and four application timings of 2-, 3- and 4-week intervals, plus applications made according to the AU-Pnuts leaf spot advisory (18). Plots consisted of four 30-ft rows spaced 3 ft apart. An All Terrain Vehicle-mounted four row boom sprayer with three TeeJet TX-8 nozzles (Spraying Systems Co., Wheaton, IL) per row, calibrated to deliver 10 gal/acre spray volume, was used for fungicide delivery to the plant canopy.

In each year, all fungicide applications were chlorothalonil (Bravo Ultrex, Syngenta Crop Protection, Greensboro, NC; at 1.12 lb a.i./acre) for this particular fungicide program. For the tebuconazole program, tebuconazole (at 0.20 lb a.i./acre; Folicur 3.6F, Bayer Crop Protection, Kansas City, MO) was applied in a block of two to four mid-season applications [between 55 and 100 days after planting (DAP)]. The azoxystrobin program consisted of two applications of this fungicide (at 0.30 lb a.i./acre; Abound 2SC, Syngenta Crop Protection, Greensboro, NC) at approximately 60 and 90 DAP. With the tebuconazole and azoxystrobin programs, other scheduled applications consisted of chlorothalonil. No fungicides were applied beyond 125 DAP. Specific application dates for fungicides in each application schedule varied among years (Table 1).

### Table 1. Application dates for fungicides in four scheduling strategies for the study conducted in Fairhope, Alabama during 2003, 2004, and 2005.

<table>
<thead>
<tr>
<th>Schedule</th>
<th>Fungicide</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-week</td>
<td>Chlorothalonil*</td>
<td>7/8, 9/14, 9/29</td>
<td>6/21, 7/6, 9/8</td>
<td>6/22, 7/5, 9/13</td>
</tr>
<tr>
<td></td>
<td>Tebuconazole†</td>
<td>7/22, 8/4, 8/18, 9/2</td>
<td>7/20, 7/29, 8/13, 8/26</td>
<td>7/20, 8/1, 8/15, 9/1</td>
</tr>
<tr>
<td></td>
<td>Chlorothalonil</td>
<td>7/8, 8/4, 9/2, 9/14, 9/29</td>
<td>6/21, 7/20, 7/29, 8/26, 9/8</td>
<td>6/22, 7/20, 8/15, 9/1, 9/13</td>
</tr>
<tr>
<td></td>
<td>Azoxystrobin‡</td>
<td>7/22, 8/18</td>
<td>7/6, 8/13</td>
<td>7/5, 8/1</td>
</tr>
<tr>
<td>3-week</td>
<td>Chlorothalonil</td>
<td>7/8, 9/29</td>
<td>6/21, 9/8</td>
<td>6/22</td>
</tr>
<tr>
<td></td>
<td>Tebuconazole</td>
<td>7/29, 8/18, 9/8</td>
<td>7/11, 8/3, 8/19</td>
<td>7/13, 8/1, 8/22, 9/13</td>
</tr>
<tr>
<td></td>
<td>Chlorothalonil</td>
<td>7/8, 9/8, 9/29</td>
<td>6/21, 8/3, 9/8</td>
<td>6/22, 8/1, 9/13</td>
</tr>
<tr>
<td></td>
<td>Azoxystrobin</td>
<td>7/29, 8/18</td>
<td>7/11, 8/19</td>
<td>7/13, 8/22</td>
</tr>
<tr>
<td>4-week</td>
<td>Chlorothalonil</td>
<td>7/8, 9/29</td>
<td>6/21, 9/8</td>
<td>6/22</td>
</tr>
<tr>
<td></td>
<td>Tebuconazole</td>
<td>8/4, 9/2</td>
<td>7/20, 8/13</td>
<td>7/20, 8/15, 9/13</td>
</tr>
<tr>
<td></td>
<td>Chlorothalonil</td>
<td>7/8, 9/29</td>
<td>6/21, 9/8</td>
<td>6/22, 9/13</td>
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<tr>
<td></td>
<td>Azoxystrobin</td>
<td>8/4, 9/2</td>
<td>7/20, 8/13</td>
<td>7/20, 8/15</td>
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<tr>
<td>AU-Pnut§</td>
<td>Chlorothalonil</td>
<td>7/8, 9/23</td>
<td>Same as 2-week schedule</td>
<td>Same as 2-week schedule</td>
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<td></td>
<td>Tebuconazole</td>
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<td>Same as 2-week schedule</td>
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<td>Chlorothalonil</td>
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<td></td>
<td>Azoxystrobin</td>
<td>7/22, 9/2</td>
<td>Same as 2-week schedule</td>
<td>Same as 2-week schedule</td>
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</tbody>
</table>

* In the chlorothalonil-only program, every fungicide application was chlorothalonil at 1.12 lb a.i./acre.
† Fungicide applications were tebuconazole at 0.20 lb a.i./acre in the tebuconazole program; remaining applications were chlorothalonil.
‡ Fungicide applications were azoxystrobin at 0.30 lb a.i./acre in the azoxystrobin program; remaining applications were chlorothalonil.
§ AU-Pnuts triggers a fungicide application based on the number of accumulated rain events, each with > 0.10 inch of rain or irrigation within a 24-hour period, and the 5-day average rainfall forecast (18).
Table 2. Disease ratings on 'DP-1' in 2003 and 'Florida C99R' in 2004 when treated with three fungicide programs applied according to four scheduling intervals; Gulf Coast Research and Extension Center, Fairhope, AL.

<table>
<thead>
<tr>
<th>Fungicide regime</th>
<th>Rate (lb a.i./acre)</th>
<th>Application</th>
<th>Leaf Spot, 2003</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Schedule</td>
<td>No.</td>
</tr>
<tr>
<td>Chlorothalonil</td>
<td>1.12</td>
<td>2-wk</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3-wk</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4-wk</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>SU-Pnuty&lt;sup&gt;y&lt;/sup&gt;</td>
<td>7</td>
<td>3.4 bcd</td>
</tr>
<tr>
<td>Chlorothalonil + Tebuconazole</td>
<td>1.12 + 0.20</td>
<td>2-wk</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3-wk</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4-wk</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>SU-Pnuty&lt;sup&gt;y&lt;/sup&gt;</td>
<td>7</td>
<td>2.8 ab</td>
</tr>
<tr>
<td>Chlorothalonil + Azoxystrobin</td>
<td>1.12 + 0.30</td>
<td>2-wk</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3-wk</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4-wk</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>SU-Pnuty&lt;sup&gt;y&lt;/sup&gt;</td>
<td>7</td>
<td>2.7 a</td>
</tr>
</tbody>
</table>

<sup>v</sup> Late and early leaf spots severity was assessed on 2 October 2003 using the Florida leaf spot scoring system (8); AUDPC = Area under the disease progress curve for leaf spot diseases assessed through the growing season.

<sup>w</sup> SSR = Southern stem rot, and is presented as incidence or number of disease loci per 60-ft row (25).

<sup>x</sup> Rust severity was rated using the ICRISAT 1 to 9 rating scale (28).

**Disease and Yield Assessment**

Early and late leaf spot were rated on the center two rows at approximately 2-week intervals starting mid-July of each year and continuing until just before inversion. Leaf spots were rated using the Florida peanut leaf spot scoring system (8) where 1 = no disease, 2 = very few lesions in canopy, 3 = few lesions in lower and upper leaf canopy, 4 = some lesions in lower and upper canopy with light defoliation (≤10%), 5 = lesions noticeable in upper canopy with some defoliation (≤25%), 6 = lesions numerous with significant defoliation (≤50%), 7 = lesions numerous with heavy defoliation (≤75%), 8 = numerous lesions on few remaining leaves with severe defoliation (≤90%), 9 = very few remaining leaves covered with lesions and severe defoliation (≤95%), and 10 = plants defoliated or dead. Rust severity was rated on the center two rows of each plot on the final leaf spot assessment dates (2 October 2003, 18 October 2004, and 10 October 2005) using the ICRISAT 1 to 9 rating scale (28) where 1 = no disease, 2 = few necrotic spots on older leaves, 3 = few pustules mainly on older leaves, 4 = pustules mostly on lower and middle leaves and disease evident, 5 = many pustules mostly on lower and middle leaves with yellowing and necrosis of lower and middle leaves, 6 = as for rating 5 but heavy sporulation in pustules, 7 = pustules all over plant with lower and middle leaves withering, 8 = as for rating 7 except withering more severe, and 9 = 50 to 100% of leaves withered. Southern stem rot (SSR) loci counts, where 1 locus is ≤1 ft of consecutive SSR-damaged plants per row, were made on the center two rows of each plot when the plots were inverted (25).

Area under disease progress curves (AUDPCs) were calculated for leaf spot development through the growing season (26). The design of the experiment was a 3×4 factorial, where there were 3 fungicide programs and 4 application intervals. Analysis of variance was performed for testing for year and treatment (i.e., each of the two main factors and the 2-way interaction) effects (SAS version 9, SAS Institute Inc., Cary, NC). Where appropriate, means were differentiated with Fisher’s protected least significant difference (LSD) test (P ≤ 0.05). Analysis of variance indicated that AUDPCs for leaf spot, southern stem rot incidence,
rust severity and yield differed significantly between years. Therefore, data are presented separately for each year.

**Leaf Spot Diseases**

Overall leaf spot pressure was low in 2003, with a final disease rating = 3.9 for the chlorothalonil 4-week calendar schedule. This leaf spot rating reflects some leaf spotting throughout the plant canopy with minimal premature defoliation (Table 2). Each of the main factors and the 2-way interaction of fungicide program by application interval significantly affected the final leaf spot rating and AUDPCs in 2003. Leaf spot ratings and AUDPCs were generally highest in plots treated with the tebuconazole program on calendar schedules, and with chlorothalonil applied on the 4-week and AU-Pnuts application schedules (Table 2). AUDPCs were lowest in plots treated with either the tebuconazole or azoxystrobin program according to AU-Pnuts or the azoxystrobin program on 2-week intervals (Table 2).

In 2004, fungicide applications according to the AU-Pnuts advisory were the same as for the 2-week calendar applications. Main factor effects of fungicide program and application interval had significant effects on leaf spot ratings, but the 2-way interaction was not significant in 2004. Plots treated with the tebuconazole program had higher final leaf spot ratings (on 18 October) and higher AUDPCs than plots treated with chlorothalonil-only or with the azoxystrobin program (Fig. 2). On 18 October, leaf spot ratings were highest in plots treated on 4-week intervals compared to other application schedules; AUDPCs were higher with the 3- and 4-week application schedules than the 2-week (= AU-Pnut) schedules.

![Fig. 2. Areas under disease progress curves for leaf spot diseases on 'Florida C99R'. The experiment consisted of a factorial arrangement of (A) three fungicide programs (chlorothalonil only, azoxystrobin, or tebuconazole) with each of (B) four application scheduling strategies (although AU-Pnuts called for applications that were identical to the 2-week schedule). Analysis of variance indicated significant (P ≤ 0.05) main factor effects with no 2-way interaction on AUDPC in 2004 and 2005. The same letter above a bar, within a year, indicates treatments that are not significantly different (LSD = 8.7 and 10.7 for fungicide programs; LSD = 10.1 and 12.4 for application schedules; for 2004 and 2005, respectively).](image)
As in 2004, fungicide applications in 2005 according to the AU-Pnuts advisory were done on the same dates as the 2-week calendar applications. Analysis of variance indicated that fungicide program and application interval significantly affected leaf spot disease ratings, but there was not a significant 2-way interaction. Final (5 October) leaf spot rating and AUDPC were highest in plots treated with the tebuconazole program, and the 4-week application interval resulted in the highest levels of leaf spot diseases (Fig. 2). In 2005, fungicide applications made on 2-week intervals (including the AU-Pnut schedule) resulted in the lowest levels of leaf spot diseases.

**Peanut Rust**

In 2003, each of the main factors had a significant effect on rust severity and there was not a significant two-way interaction. Rust ratings were lowest in plots treated with the azoxystrobin program and in plots treated on 2-week calendar or AU-Pnuts schedules compared to other treatments (Fig. 3). In 2004, rust levels were affected by fungicide program, application schedule, and the two-way interaction of these main effects. When averaged over application intervals, rust ratings in 2004 were higher with the tebuconazole program than with other programs. The significance of the two-way interaction was probably due to higher rust levels with the tebuconazole program on 2-week intervals than on 3- or 4-week intervals (Table 2). In 2005, rust levels were affected by fungicide program and application schedule. Lower rust ratings were observed with the chlorothalonil and azoxystrobin programs compared to the tebuconazole program (Fig. 3). Rust was also lower when fungicide applications were made on 2-week (= AU-Pnut advisory) schedules compared to extended application intervals.

![Graph A: Rust ratings (1 = no disease; 9 = highest rating with up to 100% leaves affected) on 'DP-1' in 2003 and 'Florida C99R' in 2005. The experiment consisted of a factorial arrangement of (A) three fungicide programs (chlorothalonil only, azoxystrobin, or tebuconazole) applied by each of (B) four scheduling strategies (although AU-Pnuts called for applications that were identical to the 2-week schedule in 2005). Analysis of variance in 2003 and 2005 indicated significant (P ≤ 0.05) main factor effects with no 2-way interaction effect on rust rating. The same letter above a bar, within a year, indicates treatments that are not significantly different (LSD = 0.6 and 0.6 for fungicide programs; LSD = 0.7 and 0.7 for application schedules; for 2004 and 2005, respectively).](image1)

![Graph B: Rust ratings (1 = no disease; 9 = highest rating with up to 100% leaves affected) on 'DP-1' in 2003 and 'Florida C99R' in 2005. The experiment consisted of a factorial arrangement of (A) three fungicide programs (chlorothalonil only, azoxystrobin, or tebuconazole) applied by each of (B) four scheduling strategies (although AU-Pnuts called for applications that were identical to the 2-week schedule in 2005). Analysis of variance in 2003 and 2005 indicated significant (P ≤ 0.05) main factor effects with no 2-way interaction effect on rust rating. The same letter above a bar, within a year, indicates treatments that are not significantly different (LSD = 0.6 and 0.6 for fungicide programs; LSD = 0.7 and 0.7 for application schedules; for 2004 and 2005, respectively).](image2)
**Southern Stem Rot**

Overall, SSR pressure was low in all three years, with fewer than 4 disease loci per 60-ft row in any plot. In 2003, each of the main factors and the 2-way interaction of fungicide program by application interval significantly affected SSR incidence. The significance of the 2-way interaction was likely due to the high incidence of SSR (average = 3.2) in plots of the azoxystrobin program applied on 4-wk intervals, since few SSR loci (<2) were observed in all other azoxystrobin-treated plots (Table 2). In 2004, fungicide program, but not application interval, affected SSR incidence with fewest disease loci observed in azoxystrobin-treated plots (Fig. 4). Application interval was the only significant effect on SSR incidence in 2005, and the greatest number of SSR loci was observed with 4-week application intervals.

**Yield**

Analysis of variance indicated significant differences due to fungicide program and application interval in 2003, but not due to the two-way interaction. Yield from plots treated with the chlorothalonil program were lower than those treated with the azoxystrobin program, and the 4-week application schedule resulted in lowest yields among all application schedules (Fig. 5). Yield was negatively correlated to final leaf spot ratings ($r = -0.33$, $P \leq 0.01$), but not to any other disease variables in 2003.
In 2004, yield was significantly affected only by the fungicide program, with the azoxystrobin program significantly out-yielding the tebuconazole program (Fig. 5). Yield was negatively correlated to the final leaf spot rating on 18 October, AUDPC, rust and SSR incidence ($r = -0.37, -0.37, -0.33, \text{ and } -0.40, \text{ respectively; } P < 0.01$).

In 2005, application interval significantly affected yield, and the 2-week ( = AU-Pnuts) schedules significantly out-yielded the 3-week which was better than the 4-week schedule (Fig. 5). Yield was negatively correlated to leaf spot rating on 5 October, AUDPC, rust and SSR incidence ($r = -0.63, -0.65, -0.62, \text{ and } -0.48, \text{ respectively; } P < 0.001$).

Conclusions

In southwestern Alabama, peanut acreage has increased dramatically in recent years — from < 11,000 acres in 2000 to > 65,000 acres of peanut in 2005 in Baldwin, Escambia, Mobile, and Monroe counties (23). Slightly higher temperatures and substantially more rainfall occur in southwestern Alabama compared to the historically important southeastern peanut production area of southwestern Georgia and contiguous areas. Rainfall occurs almost daily due to convection thundershowers and conditions are highly conducive to peanut disease development in southwest Alabama. Recommendations to producers in this area are to maintain a strict 10- to 14-day calendar schedule for applying fungicides to control leaf spot diseases and rust on peanut in these conditions (30). However, low contract prices for peanuts coupled with rising production...

Fig. 5. Yield (lb/acre) from ‘DP-1’ (2003) and ‘Florida C99R’ (2004 and 2005). The experiment consisted of a factorial arrangement of (A) three fungicide programs (chlorothalonil only, azoxystrobin, or tebuconazole) with each of (B) four application scheduling strategies (although AU-Pnuts called for applications that were identical to the 2-week schedule in 2004 and 2005). Analysis of variance indicated significant ($P \leq 0.05$) main factor effects with no 2-way interaction effect on yield. The same letter above a bar, within a year, indicates treatments that are not significantly different (LSD = 20, 21, and 276 for fungicide programs; LSD = 15, 16, and 319 for application schedules; for 2003, 2004, and 2005, respectively).
costs has stimulated interest among producers to decrease inputs in order to cut costs. One way to reduce inputs and costs are to reduce fungicide applications in peanut production.

In this study, leaf spot levels were generally comparable to those observed in traditional southeast US production areas (e.g., 20). With regular fungicide applications, early and late leaf spot diseases were readily found in the plants’ upper canopy and minimal defoliation was obvious by the end of the season. Rust was also common in the current study, with heavy sporulation of pustules in the lower and middle portions of the plant canopy. Rust is only sporadically seen in Georgia and eastern Alabama production areas, and control is achieved while managing leaf spot diseases (11,19). SSR incidence, averaging 2 to 3.3 disease loci per 60-ft row, tended to be lower in this study than in areas to the east. In Georgia in 2004, for example, SSR incidence averaged over 10 loci in 60-ft row over a number of fungicide treatments (20).

In two of three years of this study, lengthening the interval between fungicide applications from 2- to 3-weeks increased levels of leaf spot diseases and rust. In previous studies, increased leaf spotting and premature defoliation due to early and late leaf spots had been observed when application intervals were lengthened beyond the recommended 2-week interval, even on peanut cultivars with partial resistance to early and/or late leaf spot (4,17,22). In the current study, in two of three years, there was not a significant yield decline when fungicides were applied on 3-week intervals compared to 2-week intervals. These results are comparable to those of previous studies in Georgia (4,22) in which yields were frequently but not consistently lower with longer intervals between fungicide applications. However, in the current study, the 4-week interval between fungicide applications was consistently less effective for leaf spot diseases, rust and SSR control, or for maintaining optimal yields, than other intervals tested.

The AU-Pnuts leaf spot advisory has been shown to reduce total fungicide application numbers without a decline in the control of leaf spot diseases or a reduction in yield (4,12,13,17,18). When compared with the recommended 2-week calendar schedule, one to possibly two fungicide applications have been saved during a growing season in previous studies using the AU-Pnuts leaf spot advisory (4,12,13,17,18). In contrast, applications made according to the AU-Pnuts leaf spot advisory and on a 2-week calendar schedule in southwestern Alabama were the same in two of three years. This result was likely due to the frequent thunderstorms in the area through June, July, and August of 2004 and 2005 (average = 2 rain days per week) and indicates that the AU-Pnuts leaf spot advisory for fungicide application scheduling may not be useful at locations near the Gulf of Mexico. This advisory was developed and validated at locations in Alabama (12,13,17,18) and Georgia (4) where convective summer thundershowers are less common.

In each of the three study years, the azoxystrobin fungicide program provided better control of rust and leaf spot diseases than the tebuconazole program. The azoxystrobin program was equal to the chlorothalonil-only program for control of early and late leaf spot diseases, rust, and SSR in two of three study years. These results differ from those of Culbreath et al. (9) who had observed that each of these three fungicide programs were similar in effectiveness for leaf spot control. However, Monfort et al. (22) noted that treatment with only chlorothalonil tended to be less effective than with azoxystrobin or tebuconazole. Hagan et al. (15) had previously observed less consistency of leaf spot control with tebuconazole compared to azoxystrobin or chlorothalonil-only programs in southeastern Alabama and noted that this reduced efficacy may be due to wash-off from plant surfaces.

Peanut yield was found to be negatively correlated to leaf spot ratings in 2003, and to each of the diseases observed in southwest Alabama in 2004 and 2005. Rust and SSR were lower in 2003 than in the two other years of this study, and this may explain why yield did not correlate to either of these diseases in this year. That the correlation between leaf spots and yield was consistent throughout our study demonstrates the importance of maintaining control of these diseases in this newer production area.
While nearly all fungicides recommended for the control of leaf spot diseases on peanut in Alabama are also registered for the control of rust (30), relatively little information concerning their efficacy for the control of this disease is available. At the standard 2-week calendar schedule, the best rust control was obtained with the azoxystrobin program consisting of two mid-season applications (at 0.30 lb a.i./acre) and five applications of 1.12 lb a.i./acre chlorothalonil. When applied on the same schedule, the recommended treatment with four consecutive mid-season applications of tebuconazole at 0.20 lb a.i./acre was less effective against this disease in two of three years than the 7-application chlorothalonil 2-week calendar program. As previously noted, a decline in tebuconazole efficacy against early leaf spot has been reported in Alabama (15). Kucharek and Semer (21) observed that a tank mixture of reduced rates of azoxystrobin and tebuconazole sometimes gave better rust control than the recommended chlorothalonil or tebuconazole programs. In two recent field trials in southwestern Alabama, significantly better control of rust was provided by chlorothalonil alone than with the recommended tebuconazole and azoxystrobin programs (5,6).

Fewer fungicide applications may not be the best method of maximizing peanut profits, particularly in well-rotated fields where peanut yield potential exceeds 4000 lb/acre and weather patterns favor damaging leaf spot and rust outbreaks. Extending treatment intervals from the recommended 2-weeks to 3- or 4-weeks resulted in a savings of 2 or 3 fungicide applications, respectively, but with some increase in damage attributable to leaf spots and rust. While yield response in this study with the 2- and 3-week schedules generally was similar, a significant decline in yield was seen in one of three years with the 4-week calendar schedule with all fungicide programs. The risk of yield loss with extended treatment intervals may be increased in southwestern Alabama where late summer or early fall tropical storms are common. Such a storm (or storms) could delay harvest enough that there is additional disease development with consequent yield loss. Such losses could be greater than the savings realized from eliminating 2 or 3 fungicide applications. The risk of a substantial yield loss would be higher for a peanut cultivar such as Carver or Georgia Green, which are not as resistant to leaf spot diseases as Florida C99R (14,15).

Literature Cited