Peanut (*Arachis hypogaea* L.) Cultivar Response to Leaf Spot Disease Development Under Four Disease Management Programs[1]

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ABSTRACT

Peanut (*Arachis hypogaea* L.) pod yield and response to early and late leaf spots [caused by *Cercospora arachidicola* S. Hori and *Cercosporidium personatum* (Berk. & M. A. Curtis) Deighton, respectively] were evaluated on six runner-type cultivars under four leaf spot spray programs using tebuconazole at 0.23 kg ai/ha and chlorothalonil at 1.26 kg ai/ha. The four leaf spot spray programs included unsprayed, 14-d schedule, 21-d schedule, and 28-d schedule. With the 14- and 21-d schedule, chlorothalonil was applied at the first and last applications with a maximum of four tebuconazole applications for the middle sprays. On the 28-d schedule, tebuconazole was applied four times. Under conditions of heavy leaf spot disease pressure where no fungicide was applied, Southern Runner and Georgia Browne were slightly less susceptible (although not significantly) to early or late leaf spot than Florunner, GK-7, Georgia Runner, or Sunrunner. Less leaf spot was present in the 14-d schedule compared to 21- or 28-d schedules. Although there was no yield difference between the 14-, 21-, or 28-d schedules, the plots sprayed on a 14-d schedule yielded 43% more than the unsprayed. When averaged across all spray schedules, Georgia Browne yielded 15% more peanuts than Georgia Runner.

Key Words: Chlorothalonil, groundnut, tebuconazole, pod yield.

Early leaf spot (caused by *Cercospora arachidicola* S. Hori) and late leaf spot [caused by *Cercosporidium personatum* (Berk. & M. A. Curtis) Deighton] are destructive diseases wherever peanuts are grown. Annual yield losses in Texas due to leaf spot diseases vary from year to year due to differences in rainfall patterns, humidity levels, and cropping history. Generally, leaf spot diseases are more of a problem in south Texas where high humidities and leaf wetness are prevalent for longer time periods than in other areas of the state.

In the Southeastern U.S., annual yield losses due to leaf spot have averaged 5% even with the use of protectant fungicides, whereas peanut losses would likely approach 50 to 70% without fungicides (Smith, 1984; Nutter and Shokes, 1995). Leaf spot control in the United States has depended mainly on routine applications of chlorothalonil due to its effectiveness, either on a calendar or advisory schedule (Shokes *et al.*, 1983; Phipps and Powell, 1984; Nutter and Shokes, 1995). Fungicides for leaf spot control are used because cultivars have inadequate foliar disease resistance (Phipps and Powell, 1984).

In south Texas during the early to middle of the growing season, when night-time and early morning temperatures are in the 22 to 25 C range and relative humidity is equal to or greater than 95%, early leaf spot usually becomes more predominant. Usually little rainfall is received during this June to August period. Late leaf spot can become predominant in September and October when rainfall increases, leading to longer periods of leaf wetness than is provided by dew or irrigation. Very little leaf spot is found in central or west Texas where night-time temperatures are usually cooler and the regions have lower humidities.

Florunner, released in 1969, was the most common runner-type cultivar grown in south Texas until about 1992 when GK-7 became predominant. GK-7 was privately released by AgraTech Seeds, Inc. in 1984 and is similar to Florunner, except for darker green foliage and more prominent main stems. Sunrunner was released by the University of Florida in 1982 and also is similar to Florunner.

Southern Runner, released in 1984 (Gorbet *et al.*, 1987), was the first cultivar with moderate resistance to late leaf spot (Gorbet *et al.*, 1982; Knauft *et al.*, 1988; Culbreath *et al.*, 1991). Fungicide applications are still needed on Southern Runner to obtain optimum yields (Gorbet *et al.*, 1982). Southern Runner also has moderate resistance to southern blight and tomato spotted wilt virus (Jacobi and Backman, 1989; Brenneman *et al.*, 1990; Grichar and Smith, 1992).

Southern Runner differs from Florunner in having a flatter canopy, lighter green foliage, and slightly smaller seeds with tan testae. This cultivar matures 2 or 3 wk later than Florunner (Gorbet *et al.*, 1987). Poor acceptance of Southern Runner by shellers and processors has confined its planting to a small percentage of the peanut acreage (Smith *et al.*, 1994).

Georgia Browne, released in 1993 (Branch, 1994), matures approximately 1 wk later than Florunner (Branch and Culbreath, 1995). It was developed as a small-seeded, runner-type specialty cultivar for use in the confectionery or candy market (Branch, 1994). Branch and Culbreath (1995) found in a 3-yr study using no foliar fungicides that Georgia Browne outyielded Florunner by 48% and was intermediate between Florunner and Southern Runner in leaf spot disease development.

Georgia Runner is a runner-type cultivar released in 1991 by the Georgia Agric. Exp. Sta. (Branch, 1991). Twenty-eight trials conducted over a 6-yr period in the Southeast using standard disease management practices and appropriate digging dates for Georgia Runner resulted in an average yield of 4266 kg/ha (Branch, 1993).

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This yield exceeded Florunner, Southern Runner, Sunrunner, and GK-7 by an average of 7%. Smith *et al.* (1994) concluded that, in addition to having moderate tolerance to late leaf spot, Georgia Runner has very high yield potential and stable performance across environments.

Tebuconazole (Folicur®) is a sterol dimethylation-inhibiting fungicide (DMI) which is highly effective against both foliar and soilborne pathogens (Brenneman and Murphy, 1991; Brenneman *et al.*, 1991; Grichar, 1995; Grichar and Jaks, 1995; Besler *et al.*, 1996). Tebuconazole affects several infection processes for pathogenicity of *C. personatum* and moves systematically in peanut (Labrinos and Nutter, 1993).

The optimum number of tebuconazole applications in a given season remains in question. The manufacturer recommends four sprays of tebuconazole with additional applications of a broad-spectrum fungicide at the beginning and end of the growing season (Noegel, 1992). Others have called for two or three sprays of tebuconazole (Backman, 1992).

The combination of moderate leaf spot resistance and the judicious use of DMI fungicides could reduce the amount of fungicides needed to produce an economic peanut crop. This approach to leaf spot control could reduce input cost of disease control (Fry, 1975, 1977; Johnson and Beute, 1976) and the loss of peanut yield due to plant injury during application (Brenneman and Sumner, 1989).

Differences between peanut production systems in the Southeastern U.S. and Texas dictate that the use of any reduced spray program should be evaluated before implementation. In the Southeast, runner cultivars are grown, but only about one-half of the acreage is irrigated. Production systems in Texas are more variable with 70 to 90% of the acreage irrigated. Damicone *et al.* (1994) concluded that, in Oklahoma, irrigation practices may have more impact on leaf wetness than regional weather patterns, thus affecting disease development and timing of fungicide sprays. However, we believe that in south Texas the local weather patterns as well as irrigation are a factor in leaf spot development.

The objective of this study was to evaluate six peanut cultivars for leaf spot susceptibility, yield potential, and response to a DMI fungicide under four spray programs. The six cultivars (Florunner, GK-7, Georgia Browne, Georgia Runner, Southern Runner, and Sunrunner) selected are currently being grown or have potential for use in Texas peanut production areas.

Materials and Methods

Field studies were conducted at the Texas Agric. Exp. Sta. near Yoakum, TX during the 1994 and 1995 growing seasons. The soil type was a Tremona loamy fine sand (clayey, mixed, thermic, Aquic Arenic Paleustalfs) with less than 1% organic matter. Each year the small grain cover crop was shredded and the land was then moldboard plowed prior to disking.

Fertilizer was applied each year prior to planting according to soil test analysis. Peanut seed of the six cultivars were planted 17 June 1994 and 8 June 1995 at the rate of 120 seed per 4.6 m of row. Trifluralin [2,6-dinitro-*N*,*N*-dipropyl-4-(trifluoromethyl)-benzenamine] or pendimethalin [*N*-(1-ethylpropyl)-3,4-dimethyl-2,6-dinitrobenzenamine] plus imazethapyr {(±)-2-[4,5-dihydro-4-methyl-4-(1-methylethyl)-5-oxo-1*H*-imidazol-2-yl]-5-ethyl-3-pyridinecarboxylic acid} was applied and incorporated 5 cm deep with a tractor-driven power tiller prior to planting for control of annual grasses and broadleaf weeds. Other management practices recommended by the Texas Agric. Ext. Serv. for peanut production were followed except for leaf spot control. Irrigation was applied as needed in each year to supplement natural rainfall. Five irrigations were applied in both years.

The experimental design was a split-plot in which main-plot treatments were peanut cultivars and subplot treatments were foliar spray programs. Main plots were randomly arranged in complete blocks with four replications. Individual subplots were two rows wide × 4.6 m long and rows were spaced 0.9 m apart. To increase levels of inoculum, four nonsprayed border rows of Florunner were grown between and alongside whole plots.

Chlorothalonil (Bravo 720, ISK Biosciences, Mentor, OH) was applied at 1.26 kg/ha without any surfactant and tebuconazole (Folicur 3.6F, Bayer Corp., Kansas City, MO) was applied at 0.23 kg/ha with Induce (Helena Chemical Co., Memphis, TN) at 0.19% v/v. Four fungicide treatments were evaluated—(a) nonsprayed, (b) 14-d schedule, (c) 21-d schedule, and (d) 28-d schedule.

For the 14-d schedule, chlorothalonil was applied at sprays 1, 2, and 7, whereas tebuconazole was applied at sprays 3, 4, 5, and 6. For the 21-d schedule in 1994, chlorothalonil was applied at sprays 1 and tebuconazole was applied at sprays 2, 3, 4 and 5. In 1995, chlorothalonil was applied at sprays 1 and 5 and tebuconazole was applied at sprays 2, 3, and 4. The 28-d schedule in 1994 consisted of tebuconazole applied at sprays 1, 2, 3, and 4. In 1995, the 28-d schedule consisted of chlorothalonil applied at spray 1, tebuconazole applied at sprays 2 and 3, and tebuconazole plus chlorothalonil applied at spray 4.

Fungicides were applied with a CO_2 back-pack sprayer and hand-held boom. Three D2-13 nozzle tips with slotted strainers were used per row. Nozzles were calibrated to deliver 148 L/ha at 441 Kpa. In 1994, all sprays were initiated 33 d after planting while in 1995 all sprays were initiated 34 d after planting.

Foliar disease observations were made from mid- to late season. Two leaf spot ratings from initial and late season observations were selected from each year—13 Sept. and 28 Oct. 1994, and 1 Sept. and 19 Oct. 1995. The final leaf spot ratings in each year were made approximately 7-14 d prior to harvest. Ratings were based on the subjective Florida scale where 1 = no disease and 10 = defoliated leaves and peanut plant killed by leaf spot (Chiteka *et al.*, 1988).

Plots were dug on 3 Nov. 1994 and 27 Oct. 1995 when peanuts were 139 and 141 d old, respectively. All cultivars were dug at the same time even though Southern Runner has a history of being slightly longer maturing (Smith *et al.*, 1994). Peanuts were allowed to field dry for 5-7 d before they were threshed. Samples were then dried to 10% moisture. Whole plot weight was recorded after soil and foreign matter were removed. Data were analyzed by analysis of variance and, where appropriate, Fisher's least significant difference test was used for mean separation (SAS, 1985).

Results and Discussion

Disease Incidence. In 1994, *C. personatum* was predominant (90%), whereas in 1995 there was an equal mixture of *C. arachidicola* and *C. personatum.* By the first of August in 1994 and middle August in 1995, few lesions were observed and low levels of defoliation were present. Three to four weeks later, defoliation and leaf spot lesions were evident in the unsprayed plots, but none of the sprayed plots exhibited high levels of defoliation or leaf spot lesions. Analysis of variance on leaf spot ratings indicated no significant year × fungicide effects or cultivar × fungicide treatment interaction. The effect of fungicide treatments and cultivars alone was significant.

At the first evaluation, mean leaf spot ratings in plots sprayed on the 14-d schedule had the lowest score, while the 21- and 28-d schedules reduced leaf spot and were intermediate in rating when compared with the unsprayed plots (Table 1). When averaged across all spray schedules, Southern Runner had significantly ($P \leq 0.05$) less leaf spot than GK-7, Florunner, or Sunrunner (Table 1).

Table 1. First and last ratings of peanut cultivars treated for leaf spot with or without fungicide spray schedule during a 2-yr period.

Cultivar	Fungicide spray schedule[a] Day 14	Day 21	Day 28	Unsprayed	Mean
	--------- Disease rating[b] ---------				
			First rating		
GK-7	2.9	3.4	3.4	3.9	3.4 a
Florunner	2.9	3.3	3.4	3.9	3.4 a
Southern Runner	2.9	3.1	3.0	3.4	3.1 b
Sunrunner	2.8	3.3	3.4	3.4	3.3 a
Georgia Runner	2.8	3.3	3.1	3.8	3.3 ab
Georgia Browne	2.8	3.2	3.3	3.7	3.2 ab
Mean	2.8 c	3.3 b	3.3 b	3.8 a	
			Last rating		
GK-7	4.0	4.1	5.6	8.3	5.5 ab
Florunner	4.1	4.2	5.6	8.1	5.5 ab
Southern Runner	3.6	4.1	5.4	7.5	5.2 b
Sunrunner	4.0	4.6	5.6	8.5	5.7 a
Georgia Runner	4.0	4.2	5.6	8.2	5.5 ab
Georgia Browne	3.8	4.1	5.1	7.8	5.2 b
Mean	3.9 d	4.2 c	5.5 b	8.1 a	

[a]Fungicide treatments were begun when peanuts were 33 d old in 1994 and 34 d old in 1995. Seven, five, and four applications were made each year on the 14-, 21-, and 28-d schedule, respectively. With the 14- and 21-d schedule, chlorothalonil at 1.26 kg ai/ha was applied at the first and last application with a maximum of four tebuconazole at 0.25 kg ai/ha applications for the middle sprays. On the 28-d schedule, tebuconazole was applied four times.

[b]Disease ratings were based on the Florida 1-10 scale were 1 = no disease and 10 = dead plants. Main effect means followed by the same letter are not different ($P \leq 0.05$) according to Fisher's Least Significant Difference test.

The final leaf spot severity rating, taken just prior to peanut harvest, indicated that disease incidence was high in both years. The mean rating was 8.1 in unsprayed plots, which indicated greater than 90% defoliation according to the subjective Florida leaf spot scoring system (Chiteka *et al.*, 1988). The results of analysis of variance for this final rating of leaf spot indicated significant differences in cultivars and fungicide treatments.

At the last leaf spot rating, the 14-d schedule resulted in the least amount of leaf spot while the 21-d schedule and the 28-d schedule were intermediate when compared with the unsprayed plots (Table 1). However, the 28-d schedule did have more leaf spot than the 21-d schedule.

Southern Runner and Georgia Browne had less leaf spot disease than Sunrunner (Table 1). These cultivars had the lowest disease ratings prior to harvest when averaged over all spray schedules. Currently, Southern Runner is the only commercially available cultivar with resistance to late leaf spot (Gorbet *et al.*, 1982; Knauft *et al.*, 1988; Culbreath *et al.*, 1991). Smith *et al.* (1994) stated that the level of resistance in Southern Runner is moderate and fungicide applications were still needed to obtain optimum yields. In the Southeast, Georgia Browne has an intermediate leaf spot reaction (Branch and Culbreath, 1995). Florunner, GK-7, and Georgia Runner were intermediate in leaf spot development in the current study, while Sunrunner had the most leaf spot. Smith *et al.* (1994) noted that Sunrunner was more susceptible to late leaf spot than Georgia Runner, GK-7, or Southern Runner when sprayed with diniconazole on a 28-d schedule.

Peanut Yield. Analyses of variance for yield indicated significant main effects of cultivar and fungicide treatments. Year × cultivar and cultivar × fungicide treatment interactions also were significant; consequently, each year was analyzed separately.

Regardless of treatment, peanut yields were higher in 1995 than 1994 because weather conditions were more conducive for growth of peanuts in 1995 (Table 2). Soilborne disease pressure was low in both years and not a factor in yield determination.

Florunner and GK-7 had the greatest response to fungicide applications with at least a 55% yield increase over the unsprayed plots in 1994 and 1995 (Table 2). All fungicide spray schedules resulted in increased yields of GK-7 about the same amount, whereas Florunner yields decreased as the interval between sprays increased. Georgia Browne exhibited the least response to fungicide application in both years. The 14-d schedule increased yields of Georgia Browne over the unsprayed plots by 13 to 20% while the 21- and 28-d schedules increased yields by 10% (Table 2). In 1994, only GK-7 and Georgia Runner plots yields were lower in the unsprayed than sprayed plots, while in 1995 all unsprayed plots were significantly lower in yield than any of the spray schedule plots. In 1995, Florunner sprayed on a 28-d schedule produced 13% less peanuts than those sprayed on a 14-d schedule. However, the 28-d schedule

Table 2. Yield of peanut cultivars treated with or without fungicide during a 2-yr period.

Cultivar	Fungicide spray schedule[a]				Mean
	Day 14	Day 21	Day 28	Unsprayed	
	Yield (kg/ha)				
			1994		
GK-7	4386 a	4729 a	4463 a	2175 b	3938 AB
Florunner	5169 a	4639 a	4097 a	2893 a	4200 A
Southern Runner	4343 a	4513 a	4091 a	3299 a	4062 AB
Sunrunner	3377 a	3489 a	3993 a	2301 a	3290 B
Georgia Runner	3998 a	3515 a	4032 a	2096 b	3410 B
Georgia Browne	4516 a	3776 a	3972 a	3757 a	4005 AB
Mean	4298 A	4110 A	4108 A	2754 B	
			1995		
GK-7	5912 a	5506 a	5756 a	3818 b	5248 AB
Florunner	5833 a	5237 ab	5048 b	3775 c	4973 BC
Southern Runner	5165 a	5071 a	4523 ab	4055 b	4704 C
Sunrunner	5682 a	5631 a	5344 ab	4569 b	5307 A
Georgia Runner	5390 a	5147 a	5188 a	3865 b	4898 C
Georgia Browne	5806 a	5624 ab	5501 ab	5125 b	5514 A
Mean	5631 A	5369 A	5227 A	4201 B	

[a]Entry means within each row, variety means, or spray schedule means for each year followed by the same letter are not different ($P \leq 0.05$) according to Fisher's Least Significant Difference test. Lower case letters represent the interaction of fungicide spray schedule x cultivar while upper case letters represent main effects of cultivars and fungicide treatments. Fungicide treatments began when peanuts were 33-d old in 1994 and 34-d old in 1995. Seven, five, and four applications were made each year on the 14-, 21-, and 28-d schedule, respectively.

was still significantly higher in yield than that of the untreated check.

When averaged across all spray schedules, Florunner produced the highest yield in 1994 while Sunrunner and Georgia Browne produced the top yield in 1995 (Table 2). In 1994, Sunrunner and Georgia Runner were the lowest yielding cultivars whereas in 1995 Southern Runner and Georgia Runner produced the lowest yields. In a 3-yr study in Georgia, Southern Runner and Florunner had the lowest yields without fungicides and Georgia Browne was among the highest yielding lines (Branch and Culbreath, 1995). In an earlier study with fungicide timings in the Southeastern U.S., Smith *et al.* (1994) found that Georgia Runner produced the highest yield across all spray schedules and Florunner the lowest.

Smith *et al.* (1994) found that Georgia Runner endured high leaf spot levels without large losses in yield. Our data indicate that in the southwestern U.S. this may not be true since under unsprayed conditions Georgia Runner yielded 33% less than Georgia Browne and was comparable to Florunner and GK-7 in leaf spot reaction.

Fungicide applications are still needed in the Southwest in most years to obtain economical pod yields of all cultivars. There were no significant differences in average yield across cultivars for the 14-, 21, or 28-d spray schedules in either year. However, all spray schedules resulted in higher yields than the unsprayed plots in both years. In years of extended dry periods, producers in the Southwest can extend their fungicide spray intervals and not reduce peanut yields (authors' pers. observation). This agrees with similar studies with chlorothalonil where there was no difference in yield between a 14- and 20-d fungicide schedule (Gorbet *et al.*, 1982) or a 10- and 20-d schedule (Gorbet *et al.*, 1990) on leaf spot resistant genotypes (Smith *et al.*, 1994).

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