Use of Weather-based Advisory Programs to Manage Peanut Foliar Diseases in South Texas

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ABSTRACT

Studies were conducted over a 2-year period at Yoakum, TX, using the Neogen EnviroCaster® equipped with models to time fungicide sprays for control of early leaf spot (*Cercospora arachidicola* S. Hori), late leaf spot [(*Cercosporidium personatum*) (Berk. & M. A. Curtis) Deighton] and rust (Puccinia arachidis Speg.) of peanut. Models used were version 4.5 of the early leaf spot advisory and version 2.5 of the late leaf spot advisory. The EnviroCaster® is a computerized weather station which collects weather data that drives the algorithms (models) and produces interpretive output. Advisory programs were compared to a 14-d calendar program in field plots of Florunner peanut. In both years, the incidence of early leaf spot and rust was heavy, while late leaf spot incidence was moderate in unsprayed plots. The fungicides chlorothalonil and tebuconazole were applied according to each spray program to control disease. Plots managed by 14-d calendar program with chlorothalonil or tebuconazole had significantly lower incidence of leaf spot ($P \leq 0.05$) than advisory programs each year. Plots managed by 14-d calendar program with chlorothalonil or tebuconazole had significantly lower incidence of leaf spot ($P \leq 0.05$) than advisory programs each year. Plots receiving four sprays in 1991 and three sprays in 1992 with chlorothalonil according to the late leaf spot (LLS) advisory showed levels of rust that were not significantly higher than plots receiving eight sprays on the calendar schedule. Plots treated with four tebuconazole sprays according to the LLS advisory model had significantly higher levels of rust ($P \leq 0.05$) than plots sprayed on a 14-d schedule or either of the early leaf spot (ELS) or combination early leaf spot/late leaf spot (ELS/LLS) advisories in 1991. Plots sprayed according to the ELS/LLS combination model in 1992 with tebuconazole had significantly less rust ($P \leq 0.05$) than the calendar or the ELS or LLS advisories. Although results from both years show a higher disease incidence in advisory programs compared to the 14-d program, there were no significant differences in yield ($P \leq 0.05$) among any of the programs. These results imply that the number of sprays can be reduced without sacrificing yield and the timing of sprays is important in managing foliar diseases in Texas.

KEYWORDS: advisory program, peanut diseases, fungicides, groundnut

Early and late leaf spot of peanut (Arachis hypogaea L.) are caused by Cercospora arachidicola S. Hori and Cercosporidium personatum (Berk. & Curt.) Deighton, respectively. Either disease can cause severe defoliation and reduced pod yield over 50% (Smith and Littrell, 1980). Peanut rust, caused by Puccinia arachidis Speg., can also be a destruc-

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tive disease of peanut when it becomes established early in wet seasons (Wells, 1962). This disease has been reported in all production areas of the United States (Jackson and Bell, 1969). Epidemics each year are thought to originate from subtropical areas since the fungus apparently does not overwinter in this country (Wells, 1962). While factors such as moldboard plowing, crop rotation and resistant cultivars may lessen leaf spot severity, the single most effective method of control has been the use of fungicides (Smith and Littrell, 1980). In the absence of agronomically-accepted cultivars with resistance to leaf spot diseases, multiple applications of fungicide have been justified in numerous field studies of disease management (Smith and Littrell, 1980; Johnson et al., 1986a; Knudson, et al., 1988). Fungicides have traditionally been applied on a 10-14 d schedule beginning at 30-40 d after planting (DAP) to control foliar disease. However, this relatively expensive spray program has spurred research on weather-based advisory programs improving the efficiency of fungicide use in disease management. (Jensen and Boyle, 1966; Parvin, et al., 1974; Phipps and Powell, 1984; Matyac and Bailey, 1988; Cu and Phipps, 1993; Davis et al., 1993; Damicone et al., 1994; Jacobi and Backman, 1995).

Early and late leaf spot and rust can be very prevalent on peanut in south Texas where producers usually initiate fungicide sprays at 30-45 DAP and apply an average of 5.6 sprays per season (Clyde Crumley, personal communication). Extension recommendations for Texas include starting fungicide sprays at 35-55 DAP and continuing sprays at 10-14 d intervals. However, the use of fungicide sprays can have consequences in addition to capital expense. In the early 1970s, *C. arachidicola* and *C. personatum* developed resistance to benomyl, a benzimidazole carbamate fungicide (Clark et al., 1974; Littrell, 1974). With the registration of sterol demethylation inhibiting fungicides (DMI's) in the United States, concerns are warranted about fungicide resistance resulting from the intensive use of these products (Koller and Scheinpflug, 1987). The DMI's have been tested extensively and proven to be highly effective against both foliar and soilborne diseases of peanut (Brenneman and Murphy, 1991, Brenneman et al., 1991). Cu and Phipps (1993) proposed that the effects of fungicide programs on nontarget organisms, soil compaction and vine injury by tractor tires, and the cost of fungicides can be minimized by reducing the frequency of fungicide applications.

The weather-based advisory spray program was proposed by Parvin et al. (1974) to provide an alternative to calendar-based applications of fungicides. This program was designed to recommend fungicide application only during periods when environmental conditions were favorable for disease development. Their system used the duration of periods with relative humidity (RH) above 95% and minimum air temperature during periods of high RH to detect conditions favoring inoculum production and infection by C. arachidicola . Relative humidity was used in this system as an indirect measurement of leaf wetness (Jensen and Boyle, 1966). Temperature and the duration of period of RH > 95% have an effect on infection by early and late leaf spot (Jensen and Boyle, 1965, 1966; Alderman and Beute, 1986; Shew et al., 1988). Since then, the use of temperature, relative humidity and leaf wetness have been used to develop improved models for precise timing of fungicide sprays for disease management (Nutter and Culbreath, 1991; Cu and Phipps, 1993).

Weather based, advisory programs are being used successfully in several peanut production areas (Bailey et al., 1994; Phipps et al., 1997). Field studies in the southeast and the Virginia-Carolina area have compared advisory programs and 14-d program effects on various diseases, yield and economic return (Phipps and Powell, 1984; Johnson et al., 1985, 1986b; Matyac and Bailey, 1988). Overall, the results of these studies indicate that a) leaf spot advisories can reduce the number of fungicide applications for leaf spot control without risk of loss in crop yield and value (Powell et al., 1980; Phipps and Powell, 1984; Matyac and Bailey, 1988; Cu and Phipps, 1993; b) leaf spot incidence may be greater where an advisory program is used, but yields do not differ significantly from plots sprayed on a 14-d program; (Phipps and Powell, 1984; Matyac and Bailey, 1988; Cu and Phipps, 1993; Damicone et al., 1994); and c) advisory programs improve the efficiency of production by reducing input costs, crop injury that may increase the severity of some soil borne diseases and soil compaction by spray equipment (Monzingo, 1981). Furthermore, reductions in the number of fungicide applications can reduce input costs, the environmental impact of fungicides, and the potential risk for fungal populations to become highly resistant to certain fungicides (Bent, 1978). The use of advisory sprays may result in lengthening the life of the new DMI fungicides by using them in timed, precise applications.

This paper reports the results of field evaluations of leaf spot advisory programs used in South Texas and compares performance to a 14-d spray program. The paper also reports on field evaluations of rust control by using leaf spot advisory programs.

MATERIALS AND METHODS

Field trials were conducted during 1991 and 1992 at the Yoakum Experiment Station in Lavaca County, Texas. The soil type was a Tremona loamy fine sand with a pH of 7.7, and the site was planted to peanut the previous two years. Field preparation each year included moldboard plowing followed by disking and bedding of rows. Fertilizer was applied prior to planting according to soil test recommendations. Herbicide was preplant incorporated with a power tiller at recommended rates. Florunner peanut seed was planted at approximately 100 lb/A following herbicide treatment on 25 Jun and 8 Jun in 1991 and 1992, respectively. The experimental design was a randomized complete block with four replicates per treatment. Plots were two rows 20 ft long spaced 3 ft apart. Two unsprayed border rows were between treatment rows to serve as a source of disease inoculum and provide a buffer zone for protection against spray drift.

Foliar sprays of fungicides were applied according to advisories issued by the Neogen EnviroCaster®, (Neogen Corp., Lansing, MI) or a 14-d calendar schedule. The EnviroCaster microprocessor was equipped to issue advisories for early and late leaf spot. Also an early/late leaf spot model combination in which either advisory could call for fungicide spray was used. In addition to a microprocessor and printer, components included a rain gauge, temperature/relative humidity sensor and leaf wetness sensor. The temperature /relative humidity sensor was placed over a test field peanut row at a height of 18 in while the leaf wetness sensor was placed in a peanut row in the lower canopy. The computerized weather station recorded data every 15 minutes and stored records for up to 20-d. This data was accessed by Liquid Crystal Display and printer at the test site.

The EnviroCaster Version 4.5 early leaf spot model was used to issue advisory sprays. The model uses a temperature range of 60.8°F to 89.6°F during periods of > 95% relative humidity to issue index units leading to a spray advisory. The late leaf spot model used Version 2.5. All that is known about this model is that a temperature range above 60.8°F during 10 hours of leaf wetness would issue indices leading to a spray advisory.

Chlorothalonil (Bravo 720®) was applied at 1.5 pt/A while tebuconazole (Folicur 3.6®) was applied at 6.66 fl oz/A. Tebuconazole was tank mixed with a non-ionic wetter/spreader adjuvant (Induce®) at 0.06% v:v. Sprays were applied with a CO_2 pressurized backpack sprayer equipped with a two-row boom having three nozzles (D2 tips, #13 cores and slotted strainers) per row. Foliar sprays delivered 15 gal/A at 64 psi with a ground speed of 3.0 mph. All advisory treatment plots were sprayed with fungicide within 24-72 hr of the respective advisory.

In 1991, sprays on the 14-d schedule were initiated at 30 DAP, with a total of eight sprays being applied. Accumulation of weather data for each advisory program leading to spray advisories was initiated at average emergence of the peanut crop which was 10 DAP each year. The early leaf spot advisory called for the initial spray at 23 DAP with a total of six sprays being applied. The late leaf spot advisory called for the initial spray at 30 DAP and a total of four sprays were applied. In the early/late leaf spot advisory combination program, a total of six sprays were applied starting at 23 DAP. All sprays on the early/late leaf spot advisory were determined by the early leaf spot model except the application on 16 Sep which was according to both the early and late leaf spot advisory models. When an advisory spray was applied, the date was entered into the EnviroCaster along with a 14-d protection period against disease; the advisory model then started accumulating data for the next advisory spray after the protection period expired.

Two mainstem assessments were performed during the 1991 growing season on 9 Sep and 30 Oct. Data presented in Table 1 are from the final disease assessments of each year's test. Mainstems from four randomly selected locations in each plot were removed. The number of nodes, expanded leaflets, defoliated leaflets and leaflets with lesions of early or late leaf spot were counted on each stem. Percentages of infected and defoliated leaflets were calculated (Davis et al., 1993; Jacobi and Backman, 1995). In addition to percent leaf spot infection, rust infection percentages were determined on 30 Oct when the disease was prevalent using the same method employed in determining leaf spot infection. Rainfall from 25 Jun to 11 Nov 1991 totaled as 15.6 in. Plots were sprinkler irrigated with 7.5 in of supplemental water during the growing season. Plots were dug and inverted on 11 Nov. Due to adverse weather that delayed combining, plants were placed in burlap bags and dried on a forced air dryer. Pods were then removed from the vines with a stationary thresher. Pods were dried to approximately 10% moisture and then cleaned to remove foreign material before weighing to determine plot yield. A 1.1 lb sample of peanuts from each plot were graded according to Federal State Inspection Methods (U.S. Dept. Of Ag. 1986; Jacobi and Backman, 1994). Economic values ($/A) were calculated based on U.S. loan support schedule.

In 1992, sprays on the 14-d schedule were initiated at 30 DAP. Eight 14-d sprays were applied. Five sprays were applied according to the early leaf spot advisory beginning at 24 DAP. The late leaf spot advisory called for three fungicide sprays initiated at 28 DAP. The combined advisory late/early model received five fungicide applications starting at 24 DAP. The 22 Jul spray advisory was issued simultaneously by the early and late leaf spot models. The 2 Sep advisory was issued by the late leaf spot model.

Disease evaluations for the 1992 study included mainstem assessments which were done on 14 Sep and 21 Oct. The 21 Oct count included an evaluation of rust. Rainfall recorded at the 1992 test site totaled 8.5 in from 8 Jun to 29 Oct. Supplemental water provided by sprinkler irrigation provided an additional 18.8 in. Test plots were dug and inverted on 29 Oct. Plots were air dried in the field and threshed on 3 Nov. Yield and grade determination after harvest were the same as defined for the 1991 test.

All data were subjected to an analysis of variance and significant differences were determined by Duncan's Multiple Range Test ($P < 0.05$). Arcsine transformed data were used for analysis of variance determination for percent leaf spot, rust and defoliation (Steel and Torrie, 1980). Untransformed numerical means and transformed groupings are reported in the results. Data were not combined over years due to significant treatment-by-year interactions for all parameters.

RESULTS

The incidence and severity of early leaf spot and rust were excessive in both years of this study, while late leaf spot pressure was moderate. Epidemics of rust were helpful in evaluating the utility of peanut leaf spot advisory programs.

In both years, there was an equal amount or more leaf spot and rust disease in the advisory treatments than the calendar treatments (Table 1). There was one exception in the 1992 test in which the ELS/LLS program using tebuconazole resulted in less rust than the calendar treatment. It is important to note that in the 1991 test the level of infection from leaf spot, as measured by leaf spot incidence, from the 14-d chlorothalonil and tebuconazole treated plots was not different from the untreated control. The level of rust infection between the ELS and ELS/LLS combination advisory plots sprayed with tebuconazole and the 14-day schedule plots sprayed with tebuconazole was also not different from the untreated control. This was due in both of the above respective cases, to the high level of defoliation (90%) from leaf spot in the untreated plots, resulting in fewer leaflets to count as infected by leaf spot and rust in the untreated plots thereby causing a false low infection percentage (10%) for leaf spot and rust (Table 1). Defoliation in each years test was equal to or greater in the advisory treatment than the calendar treatments.

In each year's test, although the advisory treated plots received fewer chlorothalonil and tebuconazole sprays and had numerically higher levels of leaf spot and rust than the 14-d treatments, there was no difference in yield. In the 1992 test, tebuconazole sprayed plots according to the ELS/LLS combination advisory had an increase in yield over chlorothalonil plots sprayed by the same advisory. Leaf spot and rust reduced yield of the untreated control compared to advisory and 14-d treatments in each year's test. Plots sprayed by advisory did not differ in value ($/A) from plots sprayed on the 14-d schedule from either fungicide in 1991 but values were higher than the untreated control. The same statement is true for the 1992 test with the exception of the tebuconazole ELS/LLS combination treatment which resulted in a statistically higher ($/A) figure than the chlorothalonil sprayed plot by the same advisory.

DISCUSSION

In both years of testing, even though the level of leaf spot disease was higher in advisory plots receiving fewer sprays, yields did not differ significantly from 14-d treatment yields. This data agrees with that of the studies cited earlier in this paper. Since differences in yield were not evident in each year under additional rust pressure, the data from these tests implies control of rust was achieved by ELS and LLS advisory sprays for leaf spot. There was no yield advantage with chlorothalonil or tebuconazole over each other in relation to the number or frequency of sprays applied in this study. It is the authors opinion that the peanut plant may have the ability to compensate for yield under slightly higher disease pressure, as was the case with advisory programs. The peanut plant may react in periods of stress, such as degree of leaf spot incidence, to compensate for damage done by slight infection. The results indicate that the peanut plant can tolerate a certain level of disease without loss in yield. Growers should not be overly concerned about seeing moderate levels of foliar disease in fields which are sprayed according to advisory programs.

While both early and late leaf spot are present in south Texas, rust is also a major disease which can result in yield and economic losses. The data presented here showed leaf spot and rust were controlled by fewer applications of fungicide when the timing of sprays

Table 1. The effect of fungicides and spray programs on disease incidence, yield and value of Florunner peanuts in 1991 and 1992[a].

Fungicide[b]	Spray program[c]	No. of sprays	Incidence: Leaf spot[d]	Incidence: Rust[e]	Incidence: Defoliation[f]	Yield	Value
			%	%	%	lb/A	$/A
1991							
Chlorothalonil	ELS	6	34 a	42 ab	47 b	3307 a	1200 a
Chlorothalonil	LLS	4	29 ab	40 ab	48 b	3409 a	1203 a
Chlorothalonil	ELS; LLS	6	35 a	52 a	38 b-d	3085 a	1089 a
Chlorothalonil	14 DAY	8	14 d	35 b	25 d	3281 a	1132 a
Tebuconazole	ELS	6	25 bc	15 c	40 bc	3669 a	1322 a
Tebuconazole	LLS	4	21 c	33 b	49 b	3312 a	1194 a
Tebuconazole	ELS; LLS	6	24 bc	13 c	45 b	3295 a	1177 a
Tebuconazole	14 DAY	8	10 d	7 c	31 cd	3405 a	1204 a
Untreated check			10 d	10 c	90 a	1932 b	703 b
1992							
Chlorothalonil	ELS	5	15 bc	68 a	32 c	3888 ab	1415 ab
Chlorothalonil	LLS	3	24 a	59 ab	41 b	3541 ab	1295 ab
Chlorothalonil	ELS; LLS	5	15 bc	67 a	32 c	3410 b	1214 b
Chlorothalonil	14 DAY	8	4 d	56 b	29 c	4268 ab	1536 ab

Table 1. (Cont'd.)

Fungicide[b]	Spray program[c]	No. of sprays	Incidence: Leaf spot[d]	Incidence: Rust[e]	Incidence: Defoliation[f]	Yield	Value
			%	%	%	lb/A	$/A
Tebuconazole	ELS	5	24 a	53 b	42 b	3939 ab	1395 ab
Tebuconazole	LLS	3	25 a	56 b	44 b	3622 ab	1292 ab
Tebuconazole	ELS; LLS	5	19 ab	37 c	30 c	4606 a	1663 a
Tebuconazole	14 DAY	8	9 c	51 b	29 c	4254 ab	1558 ab
Untreated check			26 a	32 c	68 a	2144 c	789 c

[a]Means within a given year and column followed by the same letter indicate Duncan's multiple range groupings of treatments which do not differ significantly (P=0.05).

[b]Chlorothalonil (Bravo 720) used at 1.5 pt/A and tebuconazole (Folicur 3.6F) used at 6.66 fl oz/A plus Induce at 0.06% (v:v).

[c]ELS (early leaf spot advisory) sprays were applied six times in 1991 and five times in 1992. ELS advisory sprays were initially applied at 23 days after planting (DAP) in 1991 and 24 DAP in 1992. LLS (Late leaf spot advisory) sprays were applied 4 times in 1991 and three times in 1992. LLS advisory sprays were applied at 30 DAP in 1991 and 28 DAP in 1992. The 14 d sprays were applied 8 times each year starting at 30 DAP. ELS/LLS combination advisory sprays were applied six times in 1991 and five times in 1992. ELS/LLS sprays were initiated at 23 DAP in 1991 and 24 DAP in 1992.

[d]Final leaf spot incidence (percent leaflets with lesions) assessed on 30 Oct. 1991 and 21 Oct. 1992.

[e]Final rust incidence (percent leaflets with lesions) assessed on 30 Oct. 1991 and 21 Oct. 1992.

[f]Final defoliation percentage assessed on 30 Oct. 1991 and 21 Oct. 1992.

was according to the ELS and LLS advisory program. Calendar spray schedules are based on the assumption of continuous infection by the pathogen. This may not be true during weather periods which are unfavorable for infection. Growers in south Texas have been and will likely continue to control leaf spot and rust with fungicides on other than a 14-d schedule as long as there is not a sustained yield loss to disease. Advisory sprays are valuable to time fungicide applications in that their predictions are based on accumulated weather data favorable for infection by the pathogen. It is important to point out that while advisory programs can save sprays, additional sprays can be advised if weather conditions are more favorable for disease progress. The use of disease forecasting models allow the use of fungicides on an as needed basis rather than a routine schedule.

In each year of the study, the ELS program called for the first spray at 23 and 24 DAP respectively. The early season sprays were advised first by the ELS model in each year due to temperature and relative humidity requirements being met by the model. The LLS model advised sprays at 30 and 28 DAP in 1991 and 1992, respectively. These early sprays may also be partly responsible for no yield differences between advisory and 14-d sprayed plots. The LLS advisory resulted in the least number of treatments each year but resulted in yields comparable to other fungicide treatments.

At present there is no advisory program being used in Texas commercial peanut production. South Texas growers could save from one and three sprays by using an advisory program. The use of the recently registered tebuconazole in a block or tank mix application with chlorothalonil for disease resistance management may suit an advisory program due to the systemic activity of this product. Since chlorothalonil must be present prior to spore germination to inhibit infection, timing of each application is critical to effective disease control (Nokes and Young, 1992; Elliott and Spurr, 1993). The systemic or curative action of tebuconazole may allow delays in fungicide application and result in fewer sprays than the protectant chlorothalonil (Cu and Phipps, 1993). Tebuconazole, in addition to having activity against leaf spot and rust is effective in controlling southern blight (Sclerotium rolfsii Sacc.) (Brenneman and Culbreath, 1994; Besler et al., 1996). Southern blight often occurs in fields affected by leaf spot and rust in south Texas. Sprays applied using this product need to be timed to achieve effective control not only of foliar disease but soilborne disease as well. An EnviroCaster® late leaf spot model (Version 3.0) has been enhanced for soilborne disease management (Anonymous, 1995). This model forecast indicates whether a leaf spot or leaf spot/southern blight spray should be applied. Tebuconazole can be applied for leaf spot/southern blight advisories issued from 50-100 DAP by this model. The company label rate restricts the number and quantity of tebuconazole treatments (Noegel, 1992). This product should work well in an advisory program due to its multi-target and systemic nature. The evaluation of tebuconazole in this study was below the label rate, but exceeded the seasonal cumulative dose in some of the treatments.

Weather-based advisory programs can provide producers with a tool needed to effectively and efficiently manage peanut disease. Since few south Texas producers spray according to a calendar schedule, weather-based advisories should fit into a management program. Weather-based advisory programs are being compared at this time to possibly be used in producer management programs.

REFERENCES

Anonymous. 1995. EnviroCaster Instruction Manual, Neogen Corp., Lansing, MI.
Alderman, S. C., and M. K. Beute. 1986. Influence of temperature and moisture on ger-

mination and germ tube elongation of *Cercospora arachidicola*. Phytopathology 76:715-719.

Bailey, J. E., G. L. Johnson, and S. J. Toth. 1994. Evolution of a weather based peanut leaf spot spray advisory in North Carolina. Plant Dis. 78:530-535.

Bent, K. J. 1978. Chemical control of plant diseases: some relationships to pathogenecology, pp. 177-86. In: P. R. Scott and A. Bainbridge (eds.) Plant Disease Epidemiology. Blackwell Scientific Publication, Oxford, UK.

Besler, B. A., W. J. Grichar, and A. J. Jaks. 1996. Southern blight and leaf spot in peanut using selected fungicides. Tex. J. Agri. Nat. Resour. 9:105-114.

Brenneman, T. B. and A. P. Murphy. 1991. Activity of tebuconazole on Cercosporidiumpersonatum, a foliar pathogen of peanut. Plant Dis. 75:699-703.

Brenneman, T. B. and A. K. Culbreath. 1994. Utilizing a sterol demethylation inhibiting fungicide in an advisory program to manage foliar and soilborne pathogens of peanut. Plant Dis. 78:866-872.

Brenneman, T. B., A. P. Murphy, and A. S. Csinos. 1991. Activity of tebuconazole on *Sclerotium rolfsii* and *Rhizoctonia solani,* two soilborne pathogens of peanut. Plant Dis. 75:744-747.

Clark, E. M., P. A. Backman, and R. Rodriguez-Kabana. 1974. *Cercospora* and *Cercosporidium* tolerance to benomyl and related fungicides in Alabama peanut fields. Phytopathology 64:1476-1477.

Cu, R. M., and P. M. Phipps. 1993. Development of a pathogen growth response model for the Virginia peanut leaf spot advisory program. Phytopathology 83:195-201.

Damicone, J. P., K. E. Jackson, J. R. Sholar, and M. S. Gregory. 1994. Evaluation of a weather-based advisory for management of early leaf spot of peanut in Oklahoma. Peanut Sci. 21:225-121.

Davis, D. P., J. C. Jacobi, and P. A. Backman. 1993. Twenty-four hour rainfall, a simple environmental variable for predicting peanut leaf spot epidemics. Plant Dis. 77:722-725.

Elliott, V. J., and H. W. Spurr, Jr. 1993. Temporal dynamics of chlorothalonil residues on peanut foliage and the influence of weather factors and plant growth. Plant Dis. 77:455-460.

Jackson, C. R., and D. K. Bell. 1969. Diseases of peanut (groundnut) caused by fungi. Univ. Ga. Exp. Stn. Res. Bull 56.

Jacobi, J. C., and P. A. Backman. 1994. Comparison of yield, value, and seed quality factors of florunner and southern runner peanut. Peanut Sci. 21:28-34.

Jacobi, J. C., and P. A. Backman. 1995. AU-Peanuts Advisory II: Modification of the rule-based leaf spot advisory system for a partially resistant peanut culture. Plant Dis. 79:672-676.

Jensen, R. E., and L. W. Boyle. 1965. The effect of temperature, relative humidity and precipitation on peanut leaf spot. Plant Dis. 49:975-978.

Jensen, R. E., and L. W. Boyle. 1966. A technique for forecasting leaf spot on peanuts. Plant Dis. 50:810-814.

Johnson, C. S., P. M. Phipps, and M. K. Beute. 1985. *Cercospora* leaf spot management decisions: An economic analysis of a weather-based strategy for timing fungicide applications. Peanut Sci. 12:82-85.

Johnson, C. S., M. K. Beute, and M. D. Richer. 1986a. Relationship between components of resistance and disease progress of early leaf spot on Virginia-type peanut. Phytopathology 76:495-499.

Johnson, C. S., P. M. Phipps, and M. K. Beute. 1986b. *Cercospora* leaf spot management decisions: Uses of a correlation between rainfall and disease severity to evaluate the Virginia leaf spot advisory. Phytopathology 76:860-863.

Knudson, G. R., C. S. Johnson, and H. W. Spurr. 1988. Use of a simulation model to explore fungicide strategies for control of *Cercospora* leaf spot of peanut. Peanut Sci. 15:39-43.

Koller, W., and H. Scheinpflug. 1987. Fungal resistance to sterol biosynthesis inhibitors: A new challenge. Plant Dis. 71:1066-1074.

Littrell, R. H. 1974. Tolerance in *Cercospora arachidiocola* to benomyl and related fungicides. Phytopathology 64:1377-1378.

Matyac, C. A., and J. E. Bailey. 1988. Modification of the peanut leaf spot advisory for use on genotypes with partial resistance. Phytopathology 78:640-644.

Monzingo, R. W. 1981. Effect of cultivars and field traffic on the fruiting patterns of Virginia-type peanuts. Peanut Sci. 8:103-105.

Noegel, K. A. 1992. Application strategies for use of tebuconazole on peanut. Proc. Amer. Peanut Res. Educ. Soc. 29:58 (abstr.).

Nokes, S. E., and J. H. Young. 1992. Predicting the persistence and efficacy of chlorothalonil on peanut leaf spot. Trans ASAE 35:1699-1708.

Nutter, F. W., Jr. and A. K. Culbreath. 1991. Evaluation and validation of the Georgia late leaf spot advisory model. Phytopathology 81:1144. (abstr.).

Parvin, D. W., D. H. Smith, and F. L. Crosby. 1974. Development and evaluation of a computerized forecasting method for Cercospora leaf spot of peanuts. Phytopathology 64:385-388.

Phipps, P. M., and N. L. Powell. 1984. Evaluation of criteria for the utilization of peanut leaf spot advisories in Virginia. Phytopathology 74:1189-1193.

Phipps, P. M., S. H. Deck, and D. R. Walker. 1997. Weather-based crop and disease advisories for peanuts in Virginia. Plant Dis. 81:236-244.

Powell, N. L., D. M. Porter, and R. L. Dow. 1980. Utilization of a peanut leaf spot forecasting model in Virginia. Proc. Amer. Peanut Res. Educ. Soc. 12:41 (abstr.).

Shew, B. B., M. K. Beute, and J. C. Wynne. 1988. Effects of temperature and relative humidity on expression of resistance to *Cercosporidium personatum* in peanut. Phytopathology 78:493-498.

Smith, D. H., and R. H. Littrell. 1980. Management of peanut foliar disease with fungicides. Plant Dis. 64:356-361.

Steel, R. G. D., and J. H. Torrie. 1980. Principles and Procedures of Statistics. McGraw-Hill, New York. 633 pp.

U. S. Department of Agriculture. 1986. Farmers Stock Peanuts Inspection Institutions. Agricultural Marketing Service, Washington, D.C. 93 pp.

Wells, J. C. 1962. Peanut rust in North Carolina. Plant Dis. 46:65.