CORRELATION OF EARLY LEAFSPOT DISEASE IN PEANUT WITH A WEATHER-DEPENDENT INFECTION INDEX

by

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(ABSTRACT)

Development of early leafspot, caused by Cercospora arachidicola Hori, was monitored on 'Florigiant' peanut (Arachis hypogaea L.) at two field sites in Suffolk, Virginia. In one study, plants in 27-cm-diameter plots were inoculated with 20,000 conidia and inoculation dates were replicated in five randomized complete blocks. At location one in 1985 and 1986, lesions/leaf at two weeks after inoculation correlated significantly ($P \leq 0.05$) with infection indices (IND) developed by the Virginia leafspot advisory and hours of relative humidity (RH) $\geq$ 95%. At location two, correlations between lesions/leaf and IND as well as hours of RH $\geq$ 95% were significant in 1986, but not in 1985. Certain site specific factors were believed to have altered plant susceptibility to leafspot at this site in 1985. In another study, pots with greenhouse-grown peanut were placed between unsprayed rows of field plants, heavily colonized by C. arachidicola. Plants were removed after 3, 5, and 7 days of field exposure for six consecutive weeks in 1986 and returned to the greenhouse. Lesions/leaf at two weeks after initial exposure were correlated with IND values computed by five versions of the leafspot advisory. Significant correlations were found between

lesions/leaf on plants with field exposures of 5 and 7 days and cumulative IND values and hours of RH $\geq$ 90% and 95%. The low incidence of lesions resulting with field exposures of only 3 days coupled with a lack of significant correlations between disease and cumulative IND values for 3 days after inoculation in both studies suggests that infection processes require several days, and that fungicides may be applied to achieve disease control during this time.

ACKNOWLEDGEMENTS

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Finally, the author wishes to thank her parents for their enduring support, encouragement, and love.

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INTRODUCTION AND LITERATURE REVIEW

Early and late leafspot of peanut (*Arachis hypogaea* L.), caused by *Cercospora arachidicola* Hori and *Cercosporidium personatum* (Berk. and Curt.) Deighton, respectively, are major foliar diseases of peanut. Both diseases cause significant economic losses worldwide with yield losses exceeding 50% where control measures are not utilized (5). Early leafspot is the predominant foliar disease of peanut in the Virginia-North Carolina production area, whereas late leafspot is the predominant foliar disease in southeastern and southwestern states (Fig. 1). Primary and secondary spread of leafspot diseases is thought to occur primarily through the production and dissemination of conidia (19). Although all above ground parts of the plant are susceptible to infection, leaves appear to be the most susceptible. Leafspots coupled with defoliation reduce the productivity of the peanut plant by diminishing the area of photosynthetically active tissue. To suppress leafspot severity, fungicides have been applied routinely on a 10- to 14-day schedule. Sprays are initiated 4 to 6 weeks after planting and terminated 2 to 3 weeks prior to harvest. Presently, cultivars with only partial resistance to early leafspot are available for commercial production.

Several researchers have studied the factors than can trigger the germination of conidia of *C. arachidicola* in controlled environments. Oso found that conidia developed germtubes within 24 hours at 15 to 33 C on slides in a saturated environment, with the optimum temperature being in the range of 20 to 30 C (13). Conidia failed to germinate at 1, 5,

Figure 1. Early leafspot lesions on Florigiant peanut leaf.

10, and 35 C, but produced germtubes when transferred to 20 C for 24 hours. After conidia were exposed to a temperature of 37 C for 24 hour at 100% relative humidity (RH), germtubes failed to develop even after transfer to 20 C for 72 hours. Conidia at 25 and 30 C germinated at 96.5% RH, whereas at 100% RH, germination occurred at temperatures ranging from 15 to 33 C. Germ tubes did not develop at 88% RH.

More recently, Alderman and Beute investigated conidial germination and growth of C. arachidicola (1). They observed conidial germination between 2 and 4 hours when incubated at 16, 19, 22, and 25 C under conditions of near 100% RH. Maximum germination (82 - 85%) occurred in 24 - 48 hours. Germination was also observed at 28 and 31 C, but the percentage of germinated conidia at 48 hours was reduced to 38 and 32%, respectively. Germ tube elongation was greatest at 22 C, and least at 16 C after 48 hours of incubation at 100% RH. Germ tube elongation was significantly greater at 100% RH than under free water conditions, but germination levels did not differ.

Alderman and Beute (1) also reported that germ tube elongation rates declined if plants were removed from dew chambers for an 8 hour dry period each day. Little germ tube elongation occurred during the 8 hour dry periods. Dry periods with 30 to 40% RH resulted in termination of further germ tube elongation, even after transfer to environments with 100% RH.

Stomatal penetration by C. arachidicola has been studied in environments with 98 to 100% RH at 24C (1). The percent of germ tubes that penetrated stomata increased rapidly after 4 days, reaching 76% after 6 days and 95% after 12 days. Germ tubes exhibited stomatal tropism, except in the presence of free water. Delays of 2 to 8 days were found between stomatal penetration and lesion appearance. Lesions were produced by 95% of the conidia that produced hyphae which penetrated stomata.

During 1963 and 1964, Jensen and Boyle characterized the environmental parameters that appeared to favor a rapid increase in the incidence of early and late leafspot through observations of leafspot epidemics in small field plots at Experiment, Georgia (6). They postulated that the length of time that a free water surface remained on a peanut leaf increased spore germination and the number of spores able to complete the infection process. From their studies they proposed that the persistence of relative humidity above 95% correlated directly with the persistence of free water on the surface of leaves. During periods when relative humidity remained above 95%, temperature was thought to control the germination rate of conidia. From their studies, they observed that infection increased most rapidly during time periods when relative humidity exceeded 95% for 10 hours or longer and when temperatures remained above 21 C. They formulated leafspot "infection rate" curves which illustrated the likelihood of infection on a given day based on two environmental criteria: the longest continuous period of RH $\geq$ 95% in a day and the minimum temperature during this high humidity period (7). The "infection rates" used in these curves ranged from 0 to 3 with a 3 indicating that weather conditions were very favorable for infection. They found that environmental conditions favorable for leafspot infection must persist for more than 1 day in order to detect an increase in leafspot disease.

A computerized leafspot forecasting system was developed for southern Georgia based on the leafspot "infection rate" curves proposed by Jensen and Boyle (14). A peanut producer incorporating this system into his management program would spray leafspot fungicides according to the forecast instead of following a routine spray schedule. This system was developed to apply leafspot fungicides in a less arbitrary manner and consequently minimize the amount of fungicides used. The system was not accepted by peanut producers in Georgia because of the availability of relatively inexpensive fungicides that provide adequate leafspot suppression when applied on a 10- to 14-day schedule (19).

A similar system, the Virginia leafspot advisory program, has been developed and utilized in the Virginia peanut production area (15). Weather data are collected every 10 minutes during 24 hour periods from noon to noon by three weather monitors located in Southeastern Virginia (Appendix A: Figure 1 & 2). Eighty-five percent of the peanut production area of Virginia is located within a 15 mile radius of at least one of these stations. Infection indices of 0, 1, 1.5, 2, 2.5, or 3 are computed daily for each of the three localities by the central computer at the Tidewater Agricultural Experiment Station. Infection indices are calculated each day using infection index curves which are based on two weather parameters: total number of hours RH $\geq$ 95% and the minimum temperature during the periods of high relative humidity (Appendix A: Figure 3). Leafspot advisories are issued daily for each location and may be based on the infection indices computed for the past 5 days with emphasis on the most recent two consecutive days (Appendix: Figure 4). A peanut producer following the advisory program would apply a leafspot fungicide within 5 days following a favorable advisory for his locality, while not exceeding one fungicide application within any 10 day period.

Since 1981, the Virginia Cooperative Extension Service has issued leafspot advisories daily from early June to late September. According to field trials from 1979 to 1982 in Virginia, these advisories could have saved peanut producers in Virginia an average of 4.25 sprays per year when compared to a 14-day spray schedule (15). Although the incidence of leafspot was often significantly greater in field plots sprayed according to the advisory system, crop yields and values were not significantly different from that of plots sprayed six or seven times on a 14-day schedule. The average annual increase in net return for growers using the advisory over the 14-day spray schedule from 1980 through 1983 in Suffolk, Virginia was estimated to be 218.33 dollars/ha (10).

Johnson, Phipps and Beute (11) formulated a regression model that described the relationship between rainfall and disease progress. This model used precipitation data from 1933 to 1983 to estimate a cumulative probability distribution function for peanut leafspot severity in Suffolk, Virginia. Using the distribution function and yield data from 1979 through 1983, average yearly expected net returns of 16.5 and 8.2 % were predicted as a result of using the advisory and the 14-day schedule, respectively, compared with the non-sprayed control. An average increase in expected net return of $174.36/ha per year was estimated from using the advisory over the 14-day schedule.

A reduction in the number of fungicide applications without a reduction in yield or crop value does not only decrease production cost, but eliminates unnecessary vine injury and soil compaction caused by application equipment. Negative non-target effects of fungicides along with environmental and health hazards are also reduced. For example, Bravo (chlorothalonil), a common leafspot fungicide, has been shown to increase the severity of Sclerotinia blight (*Sclerotinia minor* Jagger) in Virginia (16).

Although the benefits of a leafspot advisory are obvious, further field studies on the epidemiology of leafspot in the Virginia-North Carolina peanut production area may increase the efficiency of the present advisory program. The current study was undertaken to test the validity of the infection indices reported by Jensen and Boyle (7) under field conditions in Virginia where *C. arachidicola* is the primary cause of leafspot.

EARLY LEAFSPOT DEVELOPMENT IN FIELD INOCULATED PEANUT

INTRODUCTION

Early leafspot caused by Cercospora arachidicola Hori, poses a chronic threat to yield and profits from peanut production in Virginia and North Carolina. Disease control has been traditionally accomplished by a combination of cultural practices and fungicide applications. A reduction in primary inoculum and a delay in early leafspot development has been achieved through crop rotation and moldboard plowing to bury crop residues to depths of at least 15.2 cm (19). A peanut leafspot advisory program which advises growers when weather conditions are favorable for leafspot infection has been operational in Virginia since 1981 (15). Daily advisories are developed by the central computer at the Tidewater Agricultural Experiment Station using infection indices based on weather conditions during the previous five days with emphasis on the indices recorded for the most recent two days. A peanut producer following this program would apply a leafspot fungicide within five days following a favorable advisory for his locality, not exceeding one fungicide application within a ten day period.

The benefits of a working leafspot advisory program are evident, and were highlighted in the introduction and literature review section of this thesis. Jensen and Boyle developed "infection rate" curves, more appropriately called infection indices, through observations of leafspot development on a spanish-type peanut (cv. Argentine) in southern Georgia (6,7). Research on the epidemiology of early leafspot on virginia-type peanuts in Virginia is needed because of obvious differences in environment, peanut cultivars, and the causal fungi of leafspot between Georgia and Virginia.

This research was designed to evaluate the accuracy of the infection indices developed by the leafspot advisory in predicting an increase in early leafspot in Florigiant peanut in Virginia. Objectives were 1) to monitor early leafspot development under field conditions following weekly inoculations, 2) to assess the relationship of disease observed to infection indices developed by the Virginia leafspot advisory, and 3) to evaluate the relationship of disease development to the number of hours of relative humidity (RH) $\geq$ 95%. Preliminary reports of the findings in this research have been presented (8,9).

MATERIALS AND METHODS

Experimental design. Field plots were established at two locations in Suffolk, Virginia in 1985 and 1986 (Appendix B & C). The field sites will be referred to as location one and two. Field plots at location one were located adjacent to the weather monitoring station at the Tidewater Agricultural Experiment Station (TAES). Plots at location two were approximately 3.2 km from the weather station at TAES. Adjacent areas at each location were planted in peanut and corn each year, so that plots followed the standard corn-peanut rotation. In both years, peanuts (cv. Florigiant) were planted during early May in rows spaced 0.9-m apart. Plants were managed according to recommendations of the Virginia Cooperative Extension Service (2), except no leafspot fungicides were applied. Plots were spaced 2.7-m and 3.7-m apart within rows in 1985 and 1986, respectively, and 1.8-m apart across rows. Plots consisted of a 26.5-cm-diameter area of row with at least three peanut main stems. During 1985, eight inoculation dates and a non-inoculated check were represented in five randomized complete blocks. In 1986, a split plot design was used that consisted of inoculated and non-inoculated subplots for each of eight dates in five randomized complete blocks. Inoculation dates were spaced at weekly intervals beginning on 3 July 1985 and 27 June 1986.

Preparation of inoculum. Leaflets with early leafspot lesions were collected weekly from naturally infected plants (cv. Florigiant) which had received no fungicide applications for leafspot control. After rinsing with tap water, the leaflets were incubated in a moist chamber at 22 to 28 C. Lesions were observed for conidia of C. arachidicola with a stereodissecting microscope after 48 to 72 hours of incubation. Sporulating lesions were excised and placed in 10 ml of a Tween-80 (polyethylene oxide sorbitan monoleate; ICN Nutritional Biochemical Corporation, Cleveland, Ohio 44128) solution (three drops per 100 ml of distilled water). The solution and excised lesions were agitated for 3 minutes and the liquid portion was collected after passage through three layers of cheese cloth. The excised lesions were then resuspended in an additional 5 ml of the Tween-80 solution, agitated 3 minutes, and the liquid portion collected as in the previous step. The inoculum density in the Tween-80 solution was standardized to 1 X 10^4 conidia/ml using a hemacytometer.

Inoculation procedure. An airbrush sprayer (model 200-1, Badger

Air-Brush Co., Franklin Park, Ill 60131) pressurized at 69 kPA with CO_2 was used to apply conidia to field plots. Inoculum was applied uniformly over each plot from a height of about 20 cm above the plant canopy. A cylinder (27-cm diameter X 37-cm height) was used as a wind break for inoculum application. Each plot received 2 ml of inoculum (2 X 10^4 conidia) during the 12 seconds of spray application. Inoculations were performed between 1900 and 2100 hours (EST) on each inoculation date. Ten excised leaves of Florigiant peanut were also inoculated on each date, placed in a test tube with a modified Hoagland´s solution (18), and incubated in a humidity chamber (RH $\simeq$ 100%) to determine inoculum efficiency (12).

Evaluation procedure. Prior to inoculation, three main stems in each plot were tagged at the internode beneath the second fully expanded leaf. The occurrence of early leafspot lesions, insect damage, and defoliation were recorded for each leaflet on the main stem. From this data, main stem growth and natural leafspot development were plotted for each location. Leaflets of the first two leaves above the tags were again evaluated for early leafspot lesions, defoliation, and insect damage during the second, and third weeks following inoculation. Lesions per leaf exhibited 2 weeks after inoculation on the first two leaves above the tag (24 leaflets/plot) were correlated with cumulative values of infection indices developed by the Virginia leafspot advisory for Suffolk, Capron, and Waverly and with the cumulative sum of hours of RH $\geq$ 95% measured by the Agro-Environmental Monitoring System (20) for day 1 through 14 following inoculation.

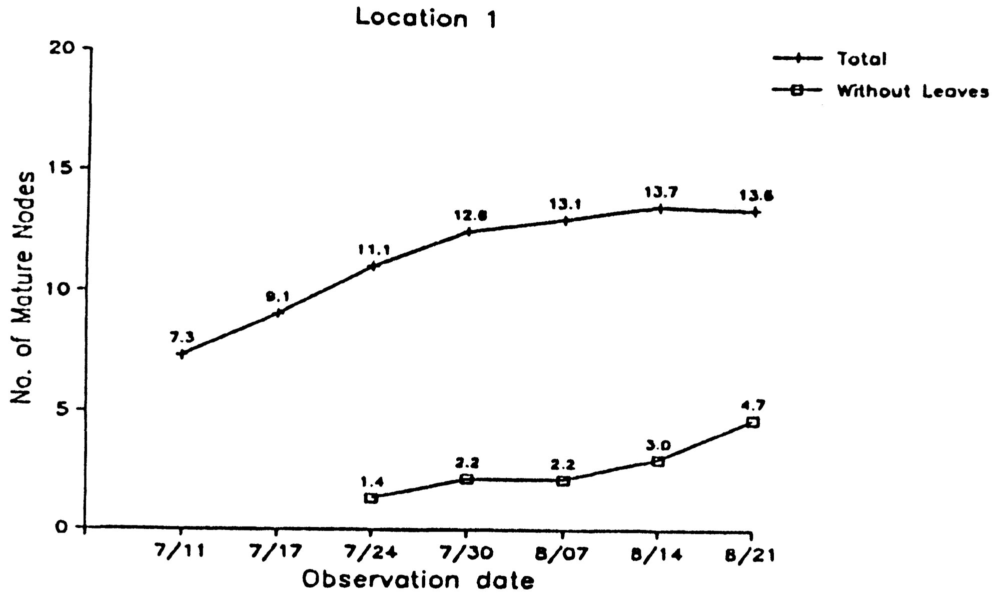
RESULTS

Mainstem growth at test locations. At location one in 1985, 0.4 more nodes with expanded leaves appeared each week than at location two from July 11 to August 21 (Fig. 2). Mainstems of plants at both locations had a similar number of leaf nodes on 11 July, however, location one had an average of 2.1 more leaf nodes per mainstem than location two by August 21.

Mainstem growth in 1986 was very similar at both locations with only 0.1 more expanded leaves appearing each week at location one than at location two from July 2 to August 14 (Fig. 3). However, at the first observation date, 1.7 more mature leaves were present at location one than at location two. This difference was maintained throughout the study with two more mature leaves recorded per mainstem at location one than at location two by August 14.

Natural occurrence of early leafspot. The natural progression of early leafspot was monitored at both locations in 1985 (Fig. 4). Abscised leaflets and leaflets exhibiting one or more lesions characteristic of early leafspot were considered as diseased due to colonization by C. arachidicola. By the first observation date, 15.3 and 61.8% of the leaflets were diseased at location one and two, respectively. The rate of natural disease progression was similar for the two sites with disease incidence levels being consistently much greater at location two. By August 21, 52.4 and 96.1% of the leaflets were diseased at location one and two, respectively.

In 1986, the natural progress of early leafspot was measured from



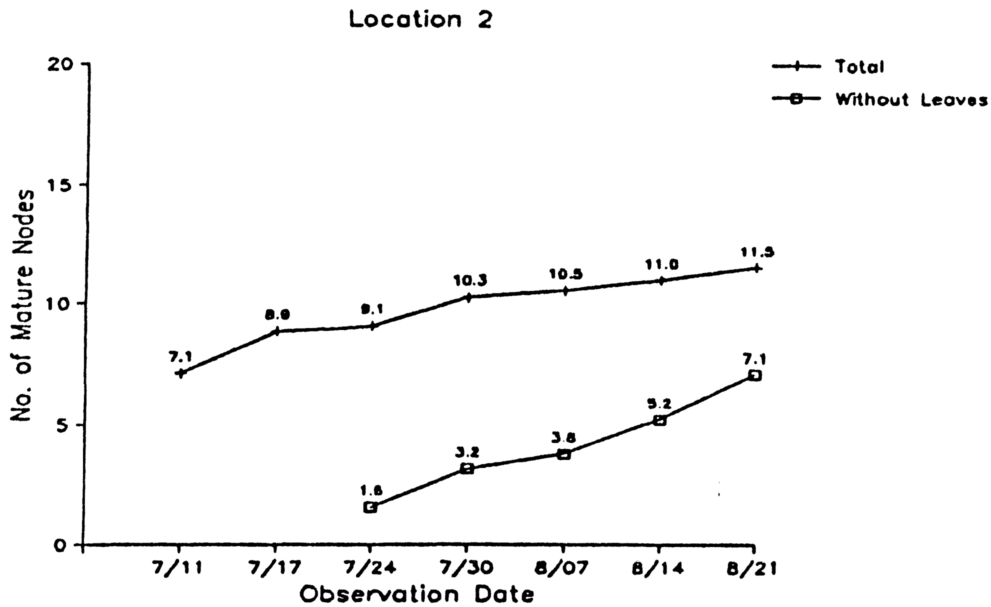


Figure 2. Growth and defoliation of peanut mainstems in non-inoculated plots in 1985. (Nodes with non-expanded leaves are not included)

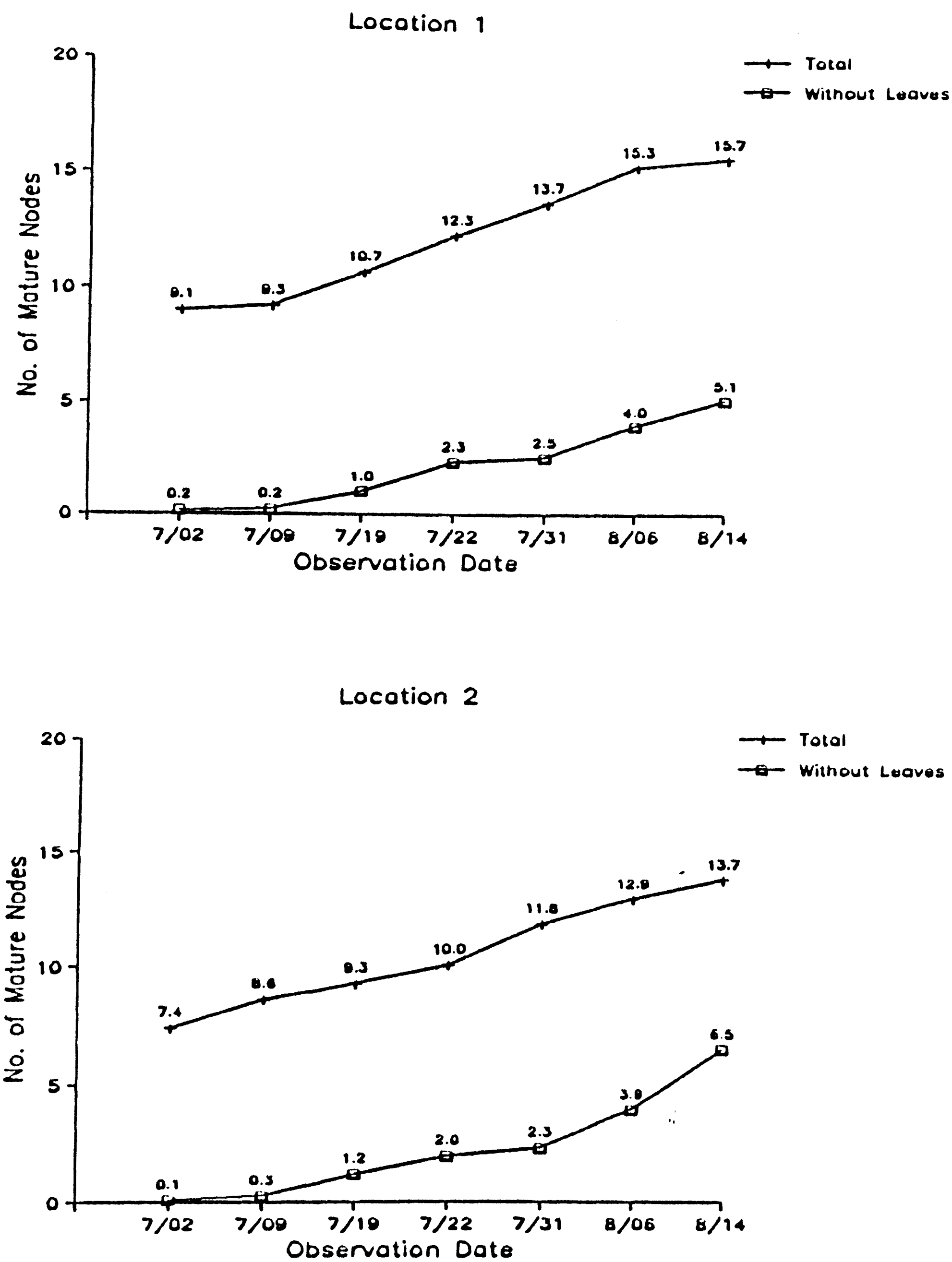
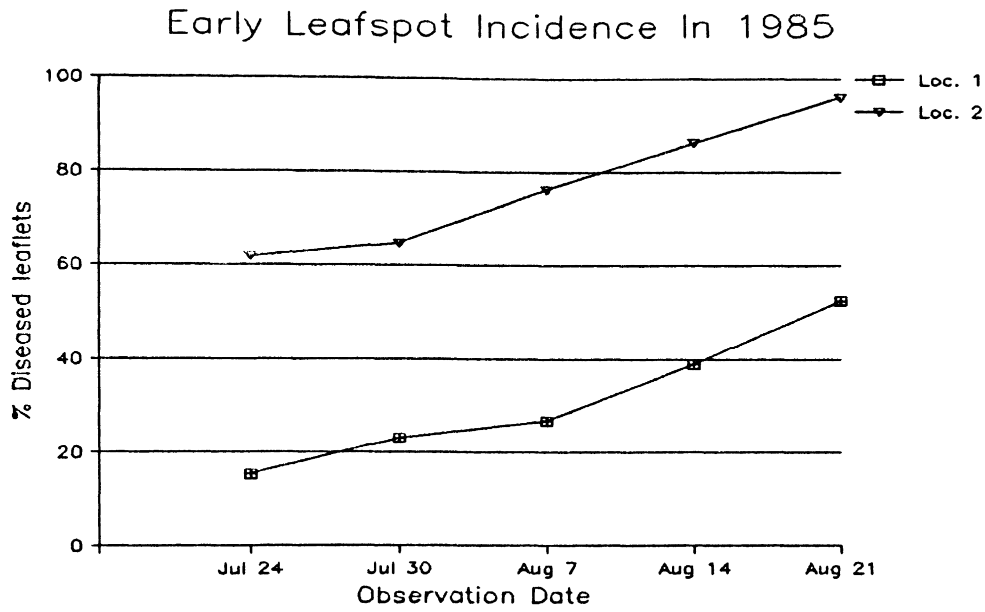


Figure 3. Growth and defoliation of peanut mainstems in non-inoculated plots in 1986.(Nodes with non-expanded leaves are not included)



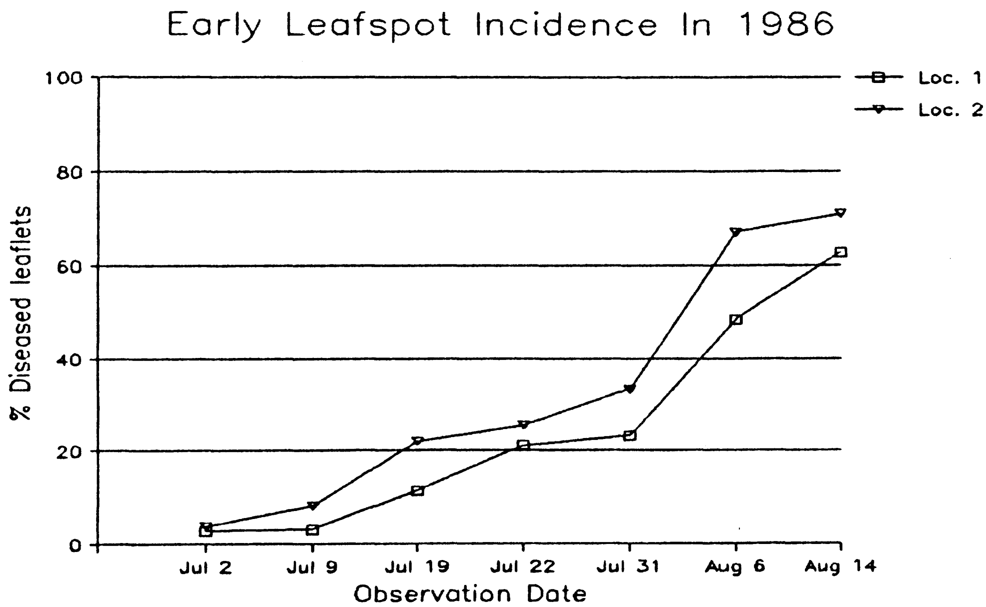
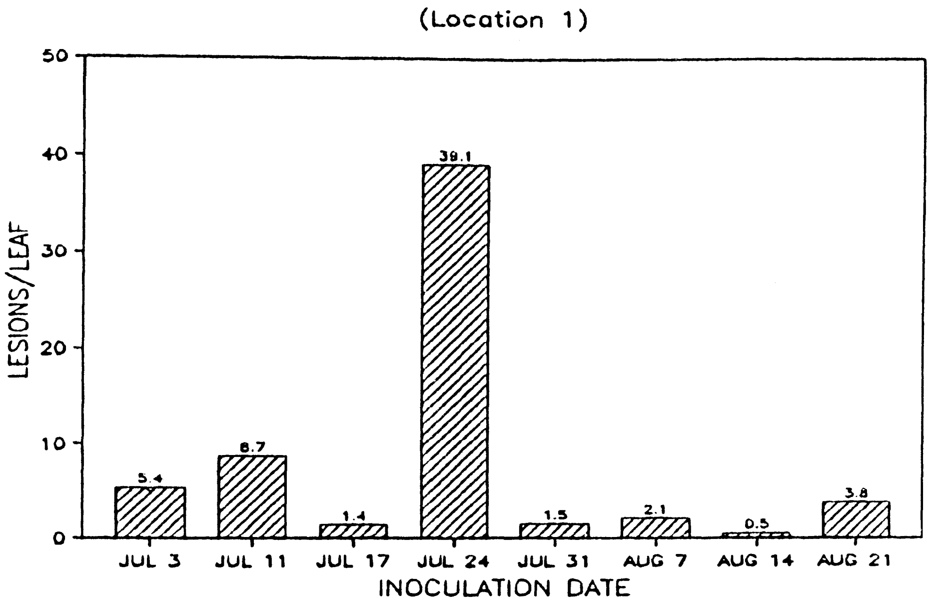


Figure 4. Natural occurrence of early leafspot in non-inoculated plots. (Leaflets both abscised and with lesions were considered diseased.)

July 2 to August 14 (Fig. 4). Locations one and two had 2.7 and 3.7% diseased leaflets, respectively, by the first observation date. As in 1985, disease progressed at similar rates at both locations with the disease level being somewhat higher at location two. By August 14, location one and two exhibited 62.7 and 71.0% diseased leaflets, respectively.

Leafspot severity following inoculations. Lesions per leaf on the two uppermost fully expanded leaves above the tag were calculated from data collected just prior to the inoculation date and at 2 and 3 weeks following treatment. Lesions per leaf for each plot were adjusted for leaflet defoliation using the equation: $[X/(24-Y)]*24$; where X = total number of lesions on the observed leaflets in a plot and Y = the number of leaflets defoliated. In each case, the number of lesions prior to inoculation was subtracted from the lesion number exhibited at the time of observation. The majority of the inoculated detached peanut leaves which were incubated in growth chambers developed early leafspot lesions by 2 weeks following inoculation.

At field location one in 1985, few lesions (< 0.4/leaf) were observed on the two uppermost fully expanded leaves above the tag on main stems just prior to each inoculation. Lesions were few to numerous on leaves observed 2 weeks after inoculation (Fig. 5). At 2 weeks after inoculation, plots inoculated on July 24 exhibited an average of 39.1 lesions/leaf. This number of lesions per leaf was significantly greater ($P = 0.05$) than the lesion number recorded at 2 weeks following the remaining inoculations. The July 11 and the July 3 inoculations had an average of 8.7 and 5.4 lesions per leaf, respectively. All other



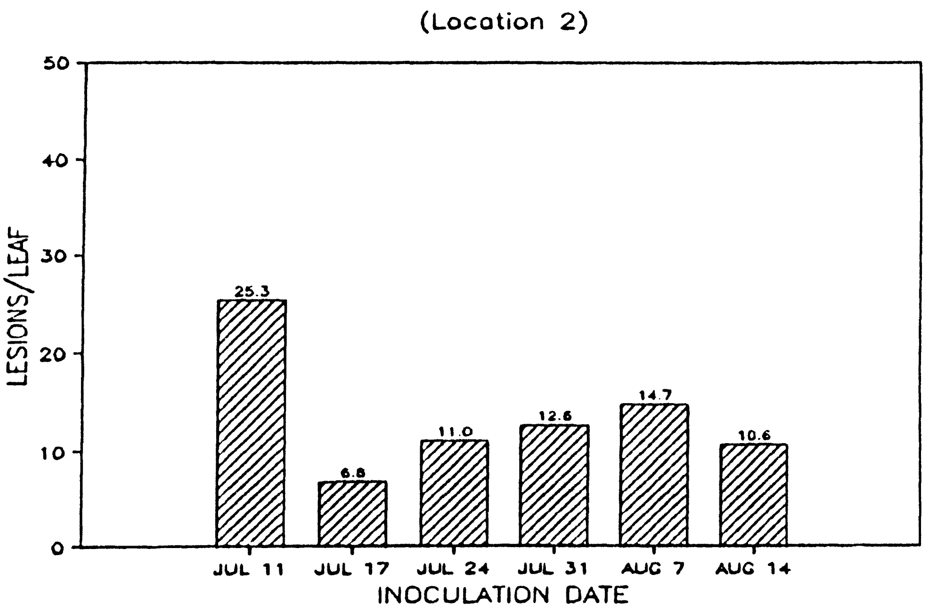


Figure 5. Lesions/leaf exhibited on leaves one and two above the tag at 2 weeks following each inoculation in 1985.

inoculations had less than 4 lesions per leaf. In most cases, lesion number per leaf was slightly greater at 3 weeks after inoculation than at 2 weeks.

At field location two in 1985, the two leaves above tags exhibited < 0.27 lesions/leaf just prior to the first four inoculation dates. Lesion numbers prior to inoculations on August 7 and 14 were quite high, averaging 3.1 and 6.4 lesions/leaf, respectively. By 2 weeks after inoculation, plots inoculated on July 11 exhibited the highest lesion count (25.3 lesions/leaf) (Fig. 5). Lesions/leaf recorded following this inoculation date were significantly greater than disease levels observed following all other inoculations. The remaining inoculations resulted in 6.8 to 14.7 lesions/leaf at 2 weeks. Plots inoculated on August 14 and 21 were not evaluated at 3 weeks. The lesion number exhibited 3 weeks following all other inoculations was usually slightly higher than at 2 weeks.

In 1986 at field location one, few lesions (less than 0.2/leaf) were observed on the two uppermost expanded leaves of mainstems just prior to inoculation. Disease levels at 2 and 3 weeks were adjusted for defoliation and lesion number prior to inoculation as mentioned previously. At 2 weeks after inoculation, the greatest number of lesions were observed following the July 19 and July 24 inoculations with averages of 18.4 and 15.4 lesions/leaf, respectively (Fig. 6). Inoculations on August 8 and 14 exhibited an average of 14 and 12.9 lesions/leaf, respectively. All other inoculations resulted in fewer than 5 lesions/leaf at 2 weeks. Disease levels following the July 19 and 24 and the August 8 and 14 inoculations were significantly greater

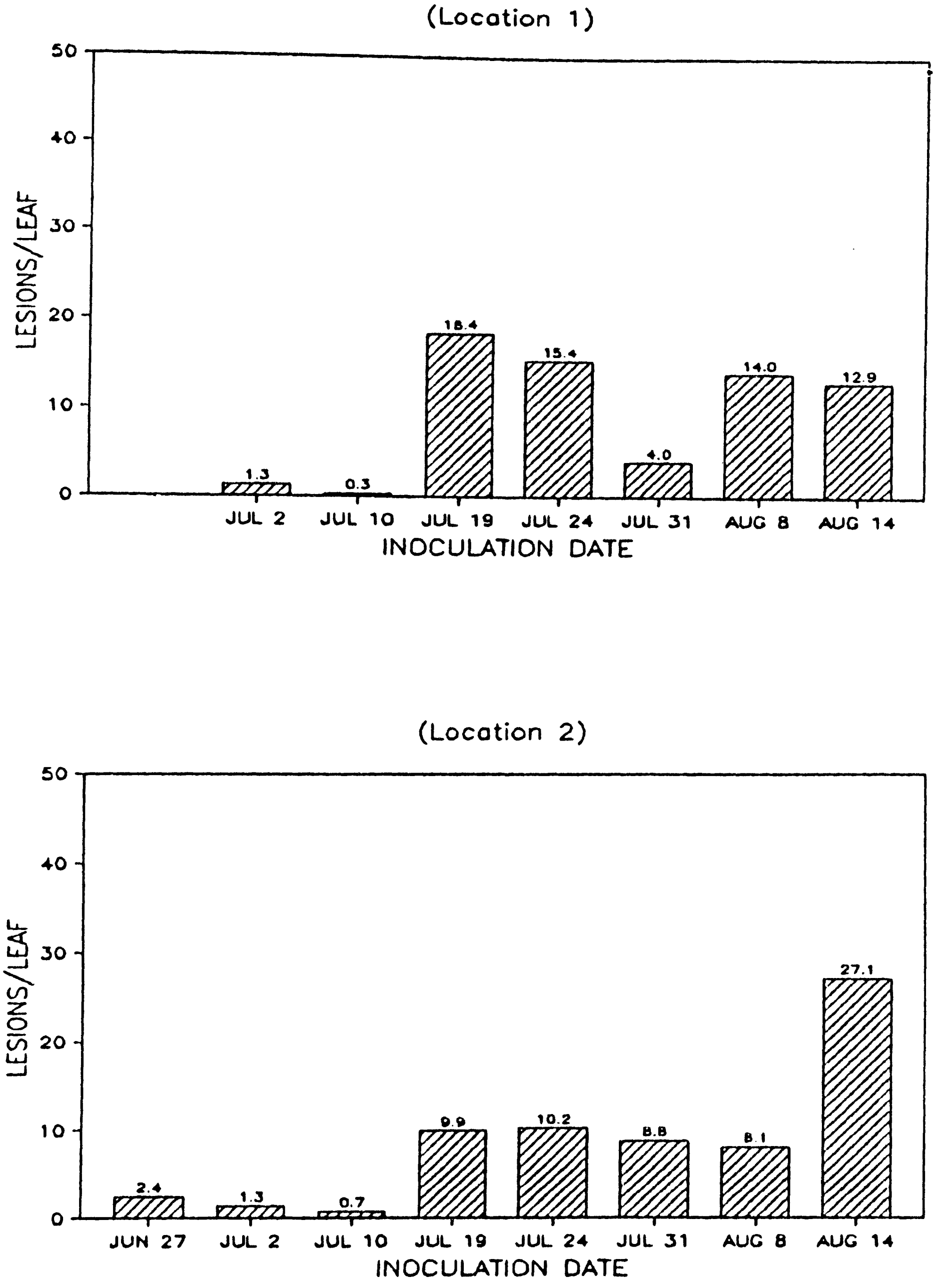


Figure 6. Lesions/leaf exhibited on leaves one and two above the tag at 2 weeks following each inoculation in 1986.

(P = 0.05) than disease levels following the remaining inoculation dates. Lesion number per leaf was usually higher at the 3 week observation date.

In 1986 at field location two, few lesions (< 0.17/leaf) were present on the two uppermost expanded leaves of mainstems just prior to inoculation. At 2 weeks, lesion number was greatest following the August 14 and the July 24 inoculations with 27.1 and 10.2 lesions/leaf, respectively (Fig. 6). The remaining inoculations exhibited 0.7 to 8.8 lesions/leaf at this time. Disease levels at 2 weeks after the August 14 inoculation date were significantly greater (P=0.05) than lesion numbers following all other inoculations. Lesion number was typically greater at 3 weeks after inoculation than at 2 weeks.

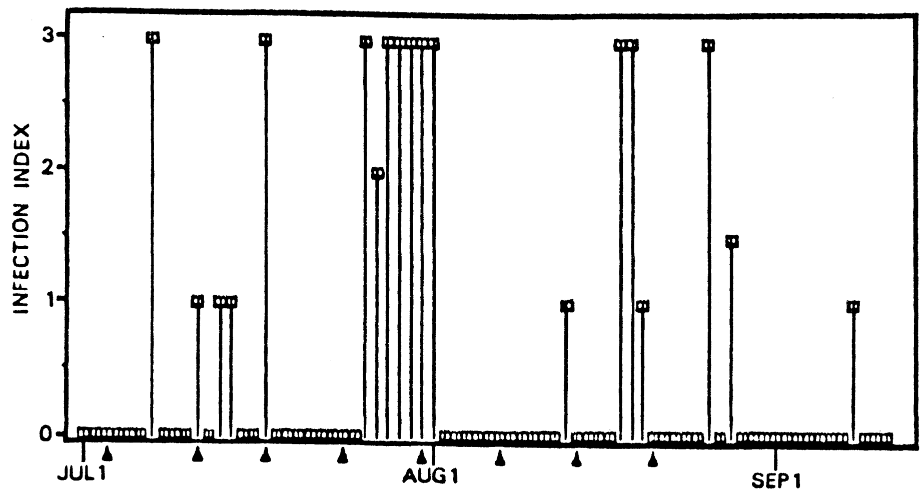
Leaf defoliation. In 1985 and 1986, all four leaflets on the two leaves above the mainstem tag were present before each inoculation at both locations one and two. Leaflet defoliation at 2 weeks after the August 21 inoculation in 1985 was 4.2% at location one in 1985. Defoliation was minimal (0 - 1.7%) at 2 weeks after the remaining inoculations. Defoliation levels at 3 weeks after inoculation ranged from 0 to 25.8%. At field location two in 1985, leaflet defoliation ranged from 0 to 8.3% at 2 weeks after inoculations with the greatest leaflet defoliation occurring after the August 14 inoculation. Defoliation levels increased at 3 weeks after inoculation and ranged from 2.5 to 54.2%.

At field location one in 1986, defoliation at 2 weeks was minimal (< 3.3%) except for plots inoculated on July 24 which exhibited 13.3% defoliation. Defoliation levels at 3 weeks after inoculation ranged from 0 to 50.8%. At location two in 1986, defoliation was greatest at 2 weeks after inoculations on July 24 and July 2 with leaflet losses of 21.7 and 5.8%, respectively. All remaining inoculations exhibited less than 2.5% defoliation at 2 weeks after inoculation. At 3 weeks after inoculation, defoliation levels were higher ranging from 2.5 - 31.7%.

Correlation of disease with daily infection indices and hours of relative humidity ≥ 95%. Significant positive correlations were found between disease severity (lesions/leaf) at field location one in 1985 and cumulative daily infection indices (IND) from day 3 through 12 after inoculation (Fig. 7 & Table 1). Cumulative hours of RH ≥ 95% from days 5 through 12 after inoculation also correlated significantly with disease severity. Similar significant correlations were obtained when disease levels at 2 weeks were compared to cumulative IND and RH ≥ 95% data from the weather station located at Capron, Virginia (Table 2). Correlations were also significant between lesions/leaf at 2 weeks and cumulative IND from days 1 through 10 and cumulative hours of RH ≥ 95% from days 2 through 10 with data collected by the weather station at Waverly, Virginia.

In 1985 at field location two, significant correlations were not found between disease levels after inoculations and cumulative values of IND or hours of RH ≥ 95% (Table 1). Lesions/leaf also did not correlate significantly with cumulative IND or hours of RH ≥ 95% using data from weather stations at Waverly or Capron (Table 2).

In 1986 at field location one, significant correlations were obtained between disease levels after each inoculation and the cumulative sum of IND from days 4 through 12 after inoculation (Fig. 8 & Table 3).



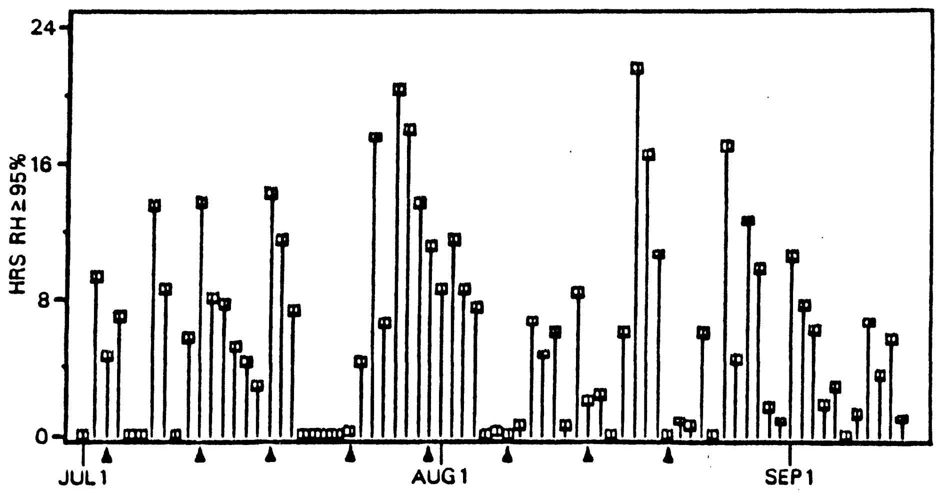


Figure 7. Infection indices and hours of RH ≥ 95% recorded each day at the Holland weather station during the field inoculation study in 1985. (▲ = inoculation dates)

Table 1. Product moment (Pearson) correlation coefficients for early leafspot lesions/leaf at 2 weeks after inoculation and accumulated daily infection indices (IND) and hours of RH $\geq$ 95% from the Holland weather station in 1985.

Day after Inoculation	Location 1		Location 2	
	IND	RH	IND	RH
1	-.20	-.07	-.18	.41
2	.62	.49	-.25	-.51
3	.81*	.52	-.21	-.42
4	.84**	.69	-.34	-.59
5	.81*	.78*	-.15	-.31
6	.87**	.80*	-.13	-.23
7	.91**	.85**	-.07	-.02
8	.93**	.88**	-.10	-.08
9	.94**	.94**	-.18	-.06
10	.94**	.94**	-.23	-.16
12	.80*	.83**	-.49	-.35
14	.61	.61	-.63	-.50

* Significant at $P \leq 0.05$

** Significant at $P \leq 0.01$

Table 2. Product moment (Pearson) correlation coefficients for early leafspot lesions/leaf at 2 weeks after inoculation and accumulated daily infection indices (IND) and hours of RH $\geq$ 95% from distant weather stations in 1985.

	Location 1				Location 2			
Day after	Capron		Waverly		Capron		Waverly	
Inoculation	IND	RH	IND	RH	IND	RH	IND	RH
1	.14	.19	.94**	.49	.18	.21	.26	.12
2	.56	.52	.94**	.72*	.40	.22	.19	.11
3	.72*	.54	.91**	.72*	.42	.43	.12	.25
4	.79*	.70	.87**	.91**	.29	.29	-.15	.01
5	.82*	.78*	.85**	.90**	.23	.19	-.14	-.07
6	.80*	.74*	.84**	.84**	.30	.25	-.08	-.02
7	.86**	.77*	.83*	.82*	.22	.29	-.13	-.04
8	.91**	.85**	.82*	.74*	.13	.29	-.20	-.05
9	.95**	.92**	.81*	.74*	.02	.09	-.31	-.28
10	.95**	.94**	.76*	.80*	-.09	-.02	-.31	-.30
12	.76*	.78*	.50	.55	-.38	-.44	-.35	-.52
14	.61	.64	.33	.32	-.57	-.60	-.40	-.48

* Significant at $P \leq 0.05$
** Significant at $P \leq 0.01$

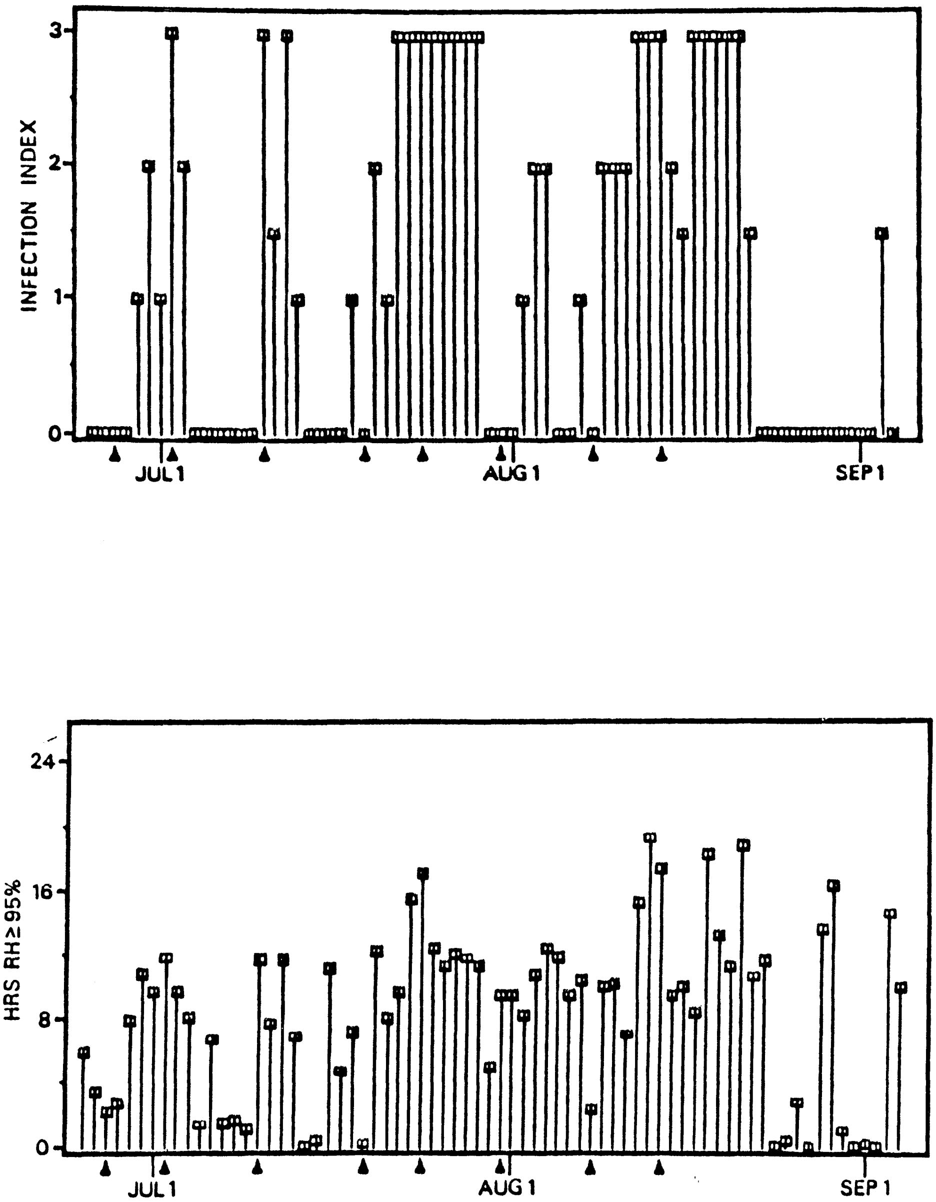


Figure 8. Infection indices and hours of RH ≥ 95% recorded each day at the Holland weather station during the field inoculation study in 1986. (▲ = inoculation dates)

Table 3. Product moment (Pearson) correlation coefficients for early leafspot lesions/leaf at 2 weeks after inoculation and accumulated daily infection indices (IND) and hours of RH $\geq$ 95% from the Holland weather station in 1986.

Day after Inoculation	Location 1		Location 2	
	IND	RH	IND	RH
1	.53	.79*	.28	.35
2	.40	.66	.20	.34
3	.71	.66	.48	.45
4	.87*	.88**	.61	.75*
5	.92**	.89**	.62	.67
6	.94**	.85*	.65	.63
7	.94**	.84*	.71*	.72*
8	.94**	.89**	.69	.75*
9	.95**	.89**	.62	.77*
10	.95**	.90**	.53	.65
12	.87*	.84*	.43	.50
14	.68	.66	.27	.37

* Significant at $P \leq 0.05$

** Significant at $P \leq 0.01$

Cumulative hours of RH $\geq$ 95% at day 1 and from days 4 through 12 following inoculation also correlated significantly with disease severity. Two week disease data also correlated significantly with cumulative infection indices developed for the Capron and Waverly weather stations (Table 4). Fewer significant correlations were found between disease levels at 2 weeks and cumulative hours of RH $\geq$ 95% for the Capron and Waverly weather stations.

In 1986 at field location two, significant positive correlations were found between lesions/leaf at 2 weeks after inoculation and cumulative IND at day 7 (Table 3). Cumulative hours of RH $\geq$ 95% at day 4 and from day 7 through 9 after inoculation also correlated significantly with disease data. Significant correlations were also obtained when disease severity at location two was compared to cumulative IND and hours of RH $\geq$ 95% recorded by the Capron and Waverly weather stations in 1986 (Table 4).

DISCUSSION

Both field locations were managed similarly in 1985 and 1986 (Appendix B & C). Therefore, management practices should have had no impact on mainstem growth or levels of disease at the two locations during each year. Although temperature and relative humidity were monitored only at location one during both years, rainfall occurrences recorded at location two were similar to rainfall data measured by the weather station at location one (Appendix D).

Differences in soil type may be responsible for differences in

Table 4. Product moment (Pearson) correlation coefficients for early leafspot lesions/leaf at 2 weeks after inoculation and accumulated daily infection indices (IND) and hours of RH $\geq$ 95% from distant weather stations in 1986.

	Location 1				Location 2			
Day after	Capron		Waverly		Capron		Waverly	
Inoculation	IND	RH	IND	RH	IND	RH	IND	RH
1	.78*	.59	.90**	.78*	.72*	.64	.59	.72*
2	.88**	.73	.55	.68	.73*	.75*	.49	.65
3	.71	.50	.73	.63	.78*	.87**	.84**	.88**
4	.82*	.68	.83*	.73	.84**	.87**	.83**	.75*
5	.88**	.79*	.81*	.75	.79*	.72*	.80*	.67
6	.88**	.75	.77*	.70	.82*	.74*	.82*	.76*
7	.87*	.69	.69	.68	.83*	.78*	.85**	.80*
8	.90**	.73	.69	.69	.77*	.77*	.79*	.77*
9	.89**	.72	.69	.68	.71*	.79*	.72*	.77*
10	.91**	.74	.70	.69	.64	.71*	.64	.72*
12	.85*	.70	.62	.67	.54	.57	.50	.57
14	.69	.53	.47	.56	.47	.44	.41	.50

* Significant at $P \leq 0.05$
** Significant at $P \leq 0.01$

plant growth and levels of disease at the two sites. The soil at location one and two was defined as a Dragston fine sandy loam and a Kenansville loamy sand, respectively (17). The soil at location two has a lower water holding capacity and drains more rapidly than the loam soil of location one. Peanuts in the Kenansville soil were observed during dry periods of both years to exhibit symptoms of moisture stress, which was believed to be responsible for the slower growth of plant mainstems at location two. The environment at location two also appeared to be less favorable for microbes which decompose abscised leaflets. Defoliated peanut leaves with lesions caused by C. arachidicola may have contributed significantly to levels of natural inoculum during the growing seasons at location two as compared to that at location one. Slower degradation of colonized peanut debris at location two may also increase natural levels of initial inoculum in the field for the next peanut crop. A high level of natural inoculum at location two was believed to account in part for the greater incidence of disease at this site in both years of this study.

Disease levels at location 2 in 1985 and 1986 were dramatically different. Rainfall in 1986 was greater than in 1985 (Appendix D: Tables 2 & 4), but this did not result in greater disease incidence. Weather conditions during late spring may have affected the amount of natural inoculum present during the two years at location two. Rainfall totalling 5.94 cm and 2.44 cm were measured during May at the TAES Research Farm in 1985 and 1986, respectively. The wetter climate during May of 1985 may have resulted in an increased production of initial inoculum during the beginning of this season when compared to

1986. Higher levels of initial inoculum in 1985 may have given the leafspot epidemic a greater boost early in the season during this year. This may in part explain why 61.8% of the mainstem leaves at location two were diseased by July 24 in 1985, whereas only 22% were diseased on a similar date in 1986 (Fig. 4).

Many occurrences of Cylindrocladium Black rot (CBR) caused by Cylindrocladium crotalariae (Loos) Bell & Sobers (3), were noted at location 2 in 1985. Periods of very dry conditions in late June, portions of July, and the first part of August in 1985 coupled with the well drained sandy soil probably increased the severity of CBR expression. Several times during the study the plants at location 2 became flaccid and exhibited wilt symptoms. Location 2 was fumigated with 93.5 L/ha of Vapam^R (sodium N-methyldithiocarbamate; Stauffer Chem. Co., Mountain View, Calif.) at two weeks preplant in 1986 for control of CBR, and no CBR incidence was observed. The presence of CBR coupled with drought stress may have increased the susceptibility of plants to infection and/or colonization by C. arachidicola at location two in 1985, and subsequently contributed to the high severity of leafspot observed during that season.

In 1985, lesions per leaf observed 2 weeks after each inoculation did not exhibit similar trends at the two locations. Disease levels were higher at location two at 2 weeks after each inoculation except July 24. During the week prior to this inoculation, 2.0 and 0.2 leaves became fully expanded at location one and two, respectively (Fig. 2). Therefore, the majority of the leaves above the tags at location one were relatively young. At location two, these same leaves were older and had become fully expanded more than a week prior to inoculation. Younger leaves are thought to be more susceptible to infection by C. arachidicola conidia (4). This fact alone may explain the high success of infection at location one after this inoculation. Differences in leaf development during the week prior to all other inoculations were much lower ranging from 0 to 0.3 more leaves becoming fully expanded on mainstems at location one. The higher levels of disease at location two compared to location one following the remaining inoculations probably was due to higher levels of natural inoculum and possibly to the greater susceptibility of plants to early leafspot infection and/or colonization. This greater susceptibility of plants was believed to be created in part by the combination of stresses caused by periods of drought and the presence of CBR disease on many plants at location two in 1985 as mentioned previously.

In 1986, lesions per leaf at location two were lower than counts at location one after all inoculations, except for inoculations made on July 10 and 31 and August 14 (Fig. 6). During the week prior to each inoculation, except these three, main stem growth at location one exceeded that of location two (Fig. 3). However, prior to these three dates, main stem growth at location two was greater. Therefore, the two upper most expanded leaves inoculated on these dates were younger at location two than at location one, and probably more susceptible to infection and/or colonization. For the remaining inoculations, the two leaves above the tag were younger at location one.

The cumulative sums of IND and hours of RH $\geq$ 95% after inoculation correlated significantly (P=0.05) with lesions/leaf at 2 weeks after inoculation in all instances, except for location two in 1985. A high level of natural inoculum of *C. arachidicola* at location two in 1985 may have precluded the detection of a disease response to inoculum applied to plots. The lack of a significant correlation of disease with infection indices and hours of RH $\geq$ 95% in 1985 supported this conclusion. Differences in leaf age at the time of inoculation due to differences in mainstem growth from week to week may have also impacted on the success of inoculum.

The significant correlations that were found indicate that environmental conditions through day 12 may have a direct effect on the infection and/or colonization process. These results agree with recent findings by Alderman and Beute (1). At 24 C in dew chambers, penetration of stomata by germ tubes of germinated conidia was observed to occur between 2 and 12 days. The greatest increase in stomatal penetration occurred between day 4 and 6 with about 17% and 77% penetration by successfully germinated conidia, respectively. These results indicate that the majority of germtubes of *C. arachidicola* remain on the surface of peanut leaves for at least several days even during the most favorable environmental conditions. During wet-dry-wet environmental sequences with 8 hour dry periods each day, the same authors found that very little germ tube elongation occurred during the dry periods. When the dry periods had RH $\geq$ 65%, the germ tubes continued to elongate when placed back in the dew chamber. This study more closely reflected the actual field situation with alternating wet and dry weather. Since elongation is hampered by dry weather conditions, the actual infection process may be slower in the field compared to results found in controlled environments with conditions continuously favorable for infection.

Many people have questioned the utility of the Virginia peanut leafspot advisory, if it reports that weather conditions have been favorable for infection after the fact. The efficiency of non-systemic fungicides (i.e. chlorothalonil and copper-sulfur materials) applied up to five days after a favorable advisory has also been questioned. Although the need is recognized to apply leafspot fungicide as soon as possible after a favorable advisory, a time lapse of several days does exist between conidial germination and infection of leaflets by *C. arachidicola*. Fungicide applications made soon after a favorable advisory (0 - 5 days), when hyphae are still exposed on the surface of a leaflet, should still be effective.

Significant correlations found between disease measured at location one and two and cumulative IND and hours of RH $\geq$ 95% recorded for the two distant weather stations in Capron and Waverly indicate that disease progress in the Virginia peanut production area is governed by regional weather patterns. These results suggest that a peanut producer can rely on leafspot advisories projected from weather stations located some distance from his fields.

Although the recent findings of Alderman and Beute (1) suggest that modifications in temperature parameters for infection may improve the accuracy of the advisory, the findings of this research indicate that the current Virginia peanut leafspot advisory provides an effective warning for periods when weather conditions are favorable for leaf infection by *C. arachidicola*.

EARLY LEAFSPOT DEVELOPMENT ON PEANUT FOLLOWING EXPOSURE TO NATURAL INOCULUM UNDER FIELD CONDITIONS

INTRODUCTION

Early leafspot, caused by Cercospora arachidicola Hori, is the predominant foliar disease of peanut (Arachis hypogaea L.) in the Virginia-North Carolina production area. This disease can cause yield losses exceeding 50% when control measures are not utilized.

A peanut leafspot advisory program has been developed for the Virginia peanut production area (15). This program advises peanut producers when conditions are favorable for the rapid spread and development of leafspot diseases. Infection indices (IND) are computed every 24 hours, and indicate the conduciveness of weather conditions for for an increase in leafspot. Infection indices are based are the number of hours of relative humidity (RH) $\geq$ 95% and the minimum temperature during the high humidity period (Appendix A: Fig. 3). Leafspot advisories ranging from unfavorable to extremely favorable are issued each day based on the infection index values recorded for the past five days with emphasis placed on the last two consecutive days (Appendix A: Fig. 4). A high infection index for any one day is not considered sufficient to trigger an increase in leafspot infection.

In a controlled environment with conditions continually favorable for leafspot, Alderman and Beute found that < 2% of the conidia of C. arachidicola germinated and penetrated stomata within 48 hours (1). The greatest percentage of stomatal penetration (59%) occurred between day 4 and 6 with only 17% of the germtubes of germinated conidia entering stomates by day 4. By day 12, 95% of germ tubes of germinated conidia had penetrated stomates. When germinated conidia were exposed to alternating wet-dry-wet regimes, the rate of germ tube elongation was greatly suppressed during the dry periods. These results coupled with the results of field inoculations reported previously (8,9), indicate that infection by C. arachidicola may be slower in field environments, wherein humid conditions usually alternate with dry conditions (RH $\leq$ 90%) at daily intervals.

The current study was designed to determine the effect of field environment on the infection of peanut leaves by natural inoculum of C. arachidicola. The objectives were 1) to evaluate disease development on greenhouse grown plants of equal age following exposure to field conditions for various lengths of time, 2) to determine the relationship of disease to infection indices recorded during field exposure using standard and modified weather parameters of the Virginia leafspot advisory, and 3) to assess the relationship of disease to hours of RH $\geq$ 95% and RH $\geq$ 90% during field exposure periods.

MATERIALS AND METHODS

Experimental design. Twelve 4-week-old peanut plants (cv. Florigiant) in 10.2-cm-diameter pots were removed from the greenhouse and positioned randomly in holes (12-cm deep, 0.9-m apart) between non-sprayed rows of Florigiant peanut at two field locations. The field plants were heavily colonized by C. arachidicola, providing high levels of natural inoculum. Plants were placed in the fields for six consecutive weeks from August 13 to September 19 (Appendix C). Hereafter, the field locations will be referred to as location one and two. Each week, four randomly selected plants were removed from each field location at 3, 5, and 7 days after field placement (about 1300 hours, EST) and returned to the greenhouse.

Evaluation procedure. Prior to field placement, plants were tagged beneath the second fully expanded leaf of the mainstem. All leaflets on the mainstem were evaluated for leafspot lesions, defoliation, and insect damage prior to placement in the field and again at 2 weeks after the date of initial field exposure. Lesions/leaf on the two leaves above the tag were correlated with cumulative IND and hours of RH $\geq$ 95% and RH $\geq$ 90% during the time of field exposure. Disease levels at 2 weeks after initial field exposure were correlated also with cumulative IND values from three modified versions of the leafspot advisory. These versions substituted hours of RH $\geq$ 90% for hours of RH $\geq$ 95%, and average temperature for minimum temperature during the period of high relative humidity.

RESULTS

Leafspot incidence following field exposure. Leafspot lesions were not observed on treated plants prior to field placement nor were lesions observed on plants that remained in the greenhouse throughout the study. Lesion number at two weeks after initial exposure was adjusted for defoliation using the equation: [(X /(8-Y)]*8; where X = the total number of lesions on the observed leaflets of each plant and Y = the number of leaflets abscised. Lesion numbers after a field exposure of 3 days ranged from 0 to 5.9 and from 0 to 2.6 lesions/leaf at location one and two, respectively (Fig. 9). Lesions/leaf after a field exposure of 5 days ranged from 0.4 to 25.5 and from 0.3 to 39.3 at location one and two, respectively. Disease levels were greatest at both locations following the August 13 field placement date. With 7 day field exposures, lesions/leaf ranged from 3.4 to 18.5 and from 0.4 to 20.2 at location one and two, respectively. Again, the highest level of disease was observed following the field placement date of August 13. Plants with 7 day field exposure following September 17 at location one were eliminated from the study due to defoliation by corn earworms.

Correlation of disease severity with cumulative IND values and hours of RH $\geq$ 90 and 95%. Significant correlations were not found between lesions/leaf following a 3-day field exposure and cumulative IND developed with standard parameters or modified versions of leafspot advisory model (Table 5). Significant correlations were obtained between lesions/leaf on plants exposed to field conditions for 5 days and cumulative IND values produced by all five versions of the leafspot advisory. Correlations were significant for disease levels on plants exposed to field conditions for 7 days and cumulative IND values produced only by modified versions of the leafspot advisory which used hours of RH $\geq$ 90% as a parameter.

No significant correlations were found between disease levels on plants subjected to field exposures of just 3 days and cumulative hours of RH $\geq$ 90% or 95% at either location (Table 6). Significant corre-

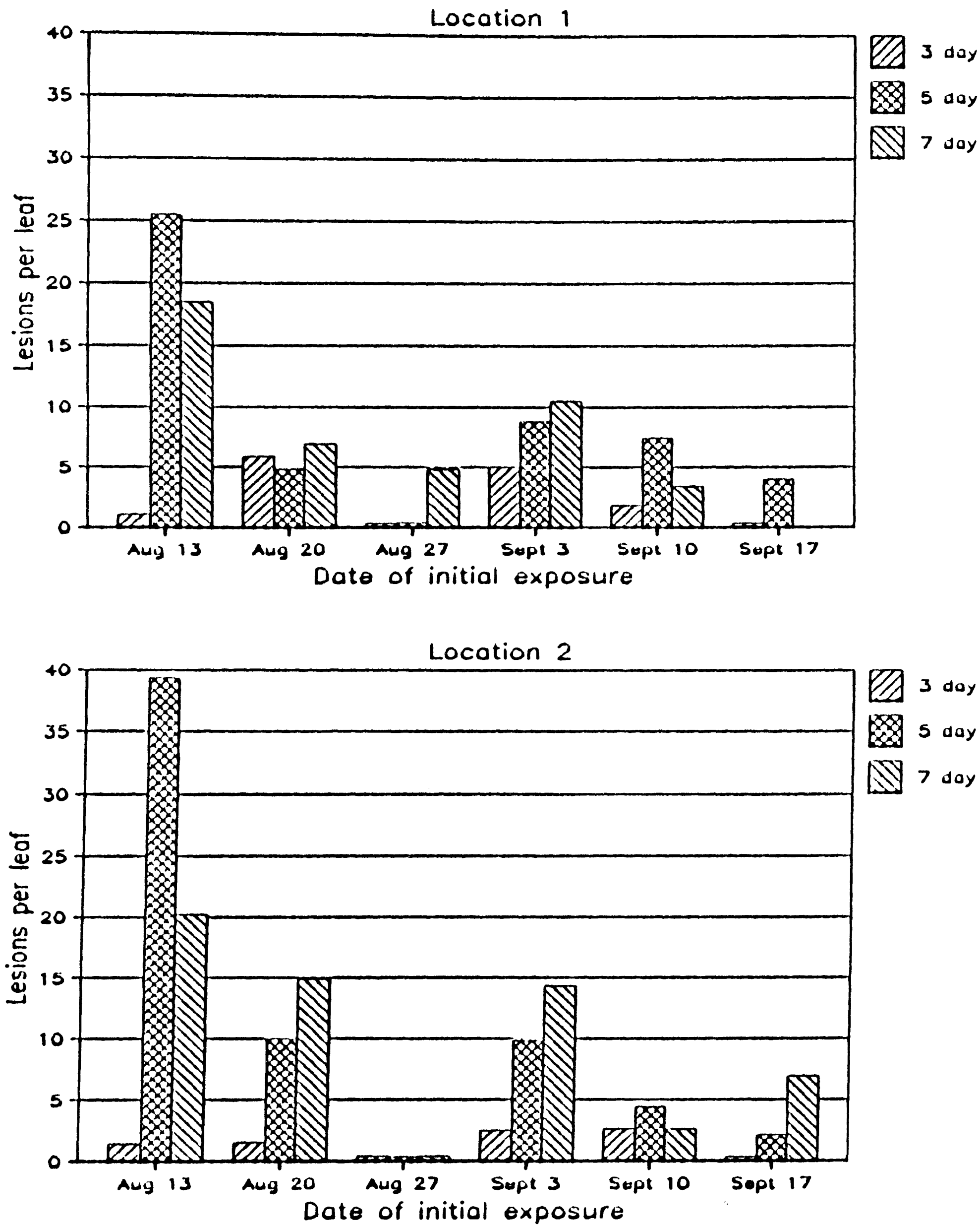


Figure 9. Early leafspot lesions/leaf observed on leaves of peanut mainstems at 2 weeks following field exposures of 3, 5, and 7 days in 1986.

Table 5. Product moment (Pearson) correlation coefficients for early leafspot lesions/leaf at 2 weeks after initial field exposure in 1986 and accumulated infection indices developed using standard and modified parameters of the Virginia peanut leafspot advisory.

		Infection index parameters tested				
Days	Day	10 min. data	hourly data			
in the	of	RH≥95%	RH≥95%	RH≥95%	RH≥90%	RH≥90%
field	exposure	Min. T	Min. T	Avg. T	Min. T	Avg. T
Location 1						
	1	.36	.36	.01	.36	.09
3	2	.33	.33	.20	.36	.39
	3	.23	.23	.11	.36	.50
	1	.58	.58	.22	.58	.25
	2	.63	.63	.43	.60	.44
5	3	.73	.73	.58	.81	.75
	4	.83*	.83*	.72	.82*	.80
	5	.88*	.88*	.79	.87*	.89*
	1	.59	.59	.28	.59	.17
	2	.63	.63	.48	.54	.46
	3	.73	.73	.62	.82	.87
7	4	.82	.82	.74	.83	.82
	5	.85	.85	.80	.87	.90*
	6	.87	.87	.83	.89*	.95*
	7	.87	.87	.82	.89*	.98**
Location 2						
	1	.04	.04	-.31	.04	-.01
3	2	.04	.03	-.15	.11	.34
	3	.03	.03	-.13	.23	.45
	1	.73	.73	.42	.73	.41
	2	.77	.77	.62	.73	.57
5	3	.86*	.86*	.75	.91*	.84*
	4	.93**	.93**	.85*	.92**	.88*
	5	.96**	.96**	.90*	.95**	.91*
	1	.76	.76	.27	.76	.19
	2	.78	.78	.55	.73	.45
	3	.79	.79	.62	.89*	.84*
7	4	.79	.79	.66	.88*	.96**
	5	.77	.77	.68	.86*	.91*
	6	.75	.75	.68	.84*	.91*
	7	.70	.72	.63	.78	.82*

* Significant at $P \leq 0.05$

** Significant at $P \leq 0.01$

Table 6. Product moment (Pearson) correlation coefficients for early leafspot lesions/leaf at 2 weeks after initial field exposure in 1986 and cumulative hours of RH $\geq$ 95% and $\geq$ 90%.

Days in the field	Day of exposure	10 min. data RH≥95%	hourly data RH≥95%	hourly data RH≥90%
Location 1				
	1	.40	.31	.27
3	2	.25	.21	.27
	3	.32	.32	.36
	1	.33	.41	.55
	2	.18	.23	.25
5	3	.29	.32	.30
	4	.44	.48	.64
	5	.68	.70	.80
	1	.52	.61	.64
	2	.34	.41	.44
	3	.44	.48	.56
7	4	.61	.66	.86
	5	.81	.85	.96**
	6	.91*	.93*	.92*
	7	.87	.89*	.93*
Location 2				
	1	-.01	.02	-.10
3	2	-.14	-.11	-.16
	3	-.11	-.07	-.19
	1	.53	.59	.73
	2	.38	.43	.47
5	3	.50	.53	.51
	4	.63	.66	.77
	5	.83*	.84*	.86*
	1	.58	.56	.71
	2	.37	.38	.48
	3	.51	.52	.64
7	4	.62	.65	.90*
	5	.71	.74	.94**
	6	.81	.81*	.88*
	7	.68	.70	.81

* Significant at $P \leq 0.05$

** Significant at $P \leq 0.01$

lations did occur between lesions/leaf at location two and the cumulative sum of hours of RH $\geq$ 90% and RH $\geq$ 95% for plants exposed to field conditions for 5 days. Significant correlations were also found with the cumulative sum of hours of RH $\geq$ 90% and disease levels following 7 day exposures of plants at location one and two. When lesions/leaf following the 7 day exposure period were correlated with cumulative hours of RH $\geq$ 95%, significant correlations were found only with disease levels at location one. Correlations obtained using weather data collected every 10 minutes were similar to correlations which used hourly averages of recorded weather data.

DISCUSSION

No significant correlations were found between disease on 3 day exposed plants and cumulative IND from any of the 5 versions of the leafspot advisory or cumulative hours of RH $\geq$ 95% or RH $\geq$ 90% for day 1 through 3. These results indicate that weather conditions during the 3 days of field exposure were not alone enough to determine the success of infection. Recent studies by Alderman and Beute indicated that the majority of stomatal penetration by germtubes of <u>C. arachidicola</u> occurred between day 4 and 6 under conditions of continuous 98 - 100% RH and a temperature of 24 C (1). Some stomatal penetration (< 2%) was observed as early as two days after inoculation. In another study, germtube elongation was slight during dry periods of a wet-dry-wet postinoculation regime. Therefore, under field conditions wherein periods of high humidity alternate with low humidity conditions, successful penetration of stomata by germtubes may be further delayed.

Correlations were found between disease levels on plants exposed 5 and 7 days to field conditions and cumulative hours of RH $\geq$ 95% and RH $\geq$ 90% during the exposure period, with the highest correlations with RH $\geq$ 90%. However, these correlations were not as consistent as those correlations found with disease and cumulative IND values from the two versions of the advisory using hours of RH $\geq$ 90%. These results suggest that temperature must be considered in order to determine the effect of high relative humidity on infection.

The best correlation with disease and cumulative infection indices occurred with the version of the advisory using hours of RH $\geq$ 90% and the average temperature during this time period. However, conidial germination studies have indicated that germination declines rapidly when RH falls below 100% (1). At 93% RH, conidial germination was reported to fall below 10% and germtube elongation was slight.

This study was performed from mid-August to mid-September. During this time the peanut canopy was fully developed, and plants were using photosynthates for development of pods and kernels. The improved correlations with IND values based on RH $\geq$ 90% over those which used RH $\geq$ 95% may be explained by the location of the test plants. The plants used in this study were positioned between peanut rows and shaded by the foliar canopy of adjacent rows. The RH beneath this canopy and surrounding the test plants was probably higher than that in the region of expanding mainstem leaves of field plants. Ambient RH was used to develop IND values for the various versions of leafspot advisories. It is feasible that when the ambient RH was 90%, RH levels beneath the canopy may have exceeded 95%.

Overall, these results indicate that a period of more than 3 days is necessary to determine the success of infection by *C. arachidicola*. Higher correlations were found when disease levels on plants with 5 or 7 day field exposures were compared to IND values than to hours of RH $\geq$ 90% or 95%. These findings indicate that temperature is an important determinant of how periods of high RH affect the infection process. Although higher correlations were found when using IND values which were based on hours of RH $\geq$ 90% over RH $\geq$ 95%, these results do not necessarily justify changing the parameters of the current leafspot advisory model. The majority of leaves on mainstems or lateral branches of peanut field plants located beneath the canopy are older than the newly expanded leaves observed on the test plants. As peanut leaves age, they become less susceptible to early leafspot disease. In a detached leaf inoculation study, newly expanded leaves developed more than twice as many lesions as older leaves treated similarly (4). Also, findings of this research do not clearly indicate that average rather than minimum temperature during the high humidity periods would be a more appropriate parameter in the leafspot advisory model.

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APPENDIX A. DESCRIPTION OF THE VIRGINIA PEANUT LEAFSPOT ADVISORY

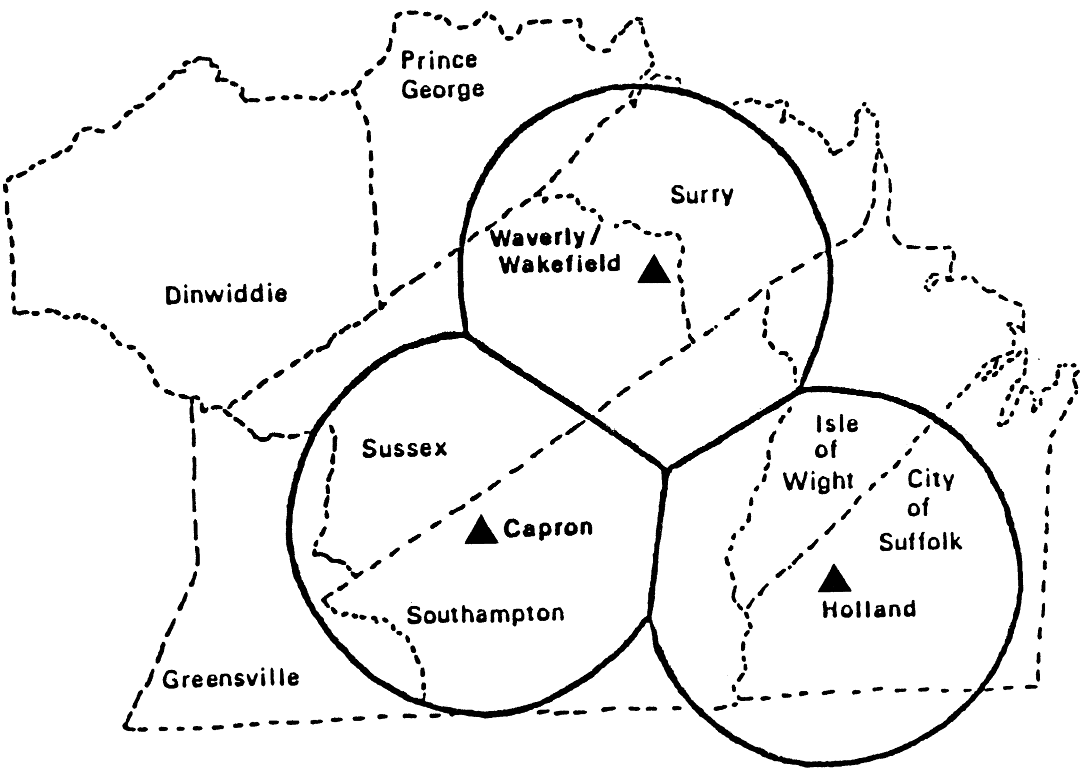

Figure 1. Location (▲) of weather stations for peanut leafspot advisories in southeast Virginia. (Circles around each station cover a 24 km radius.)

Figure 2. Weather station located in Holland, Virginia at the Tidewater Agricultural Experiment Station.

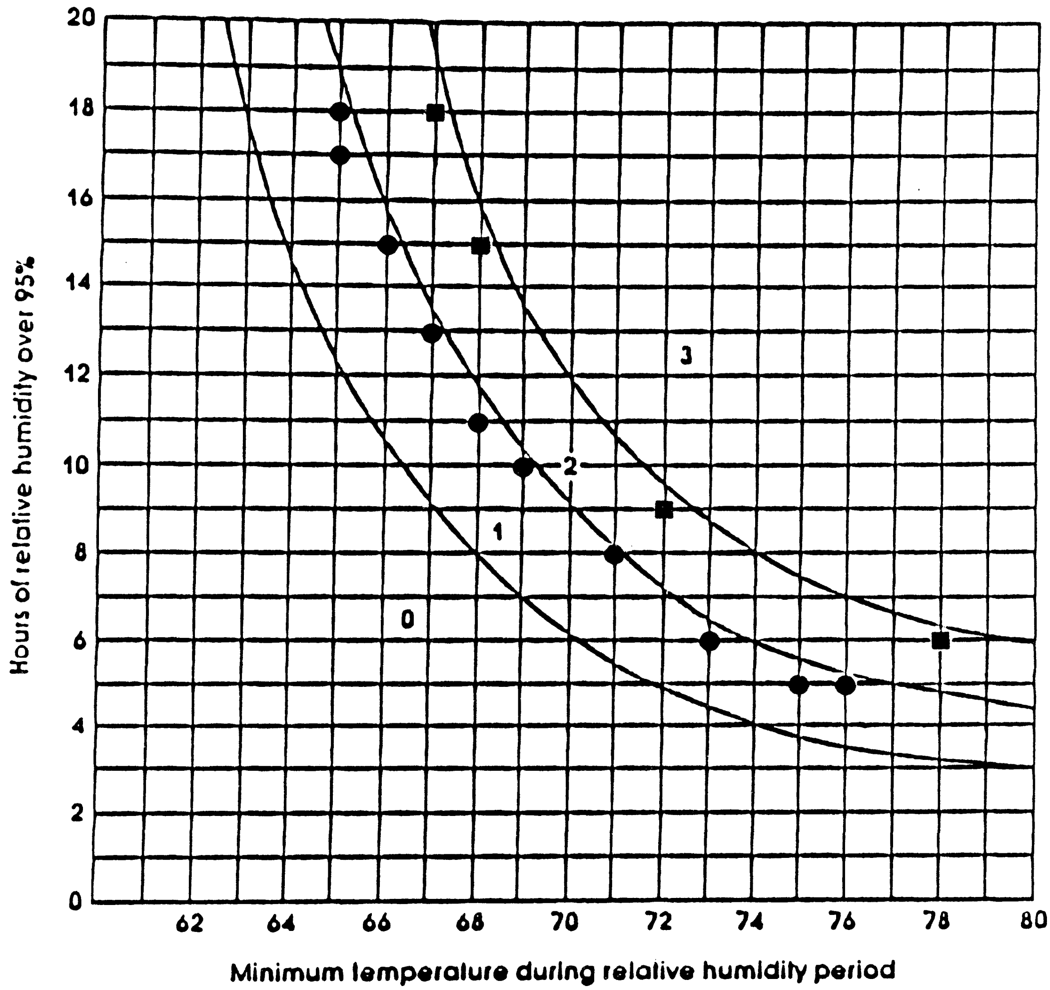

Figure 3. Infection index curves utilized by the Virginia peanut leafspot advisory. (After Parvin,Jr. et al., 1974). (● = 1.5, ■ = 2.5)

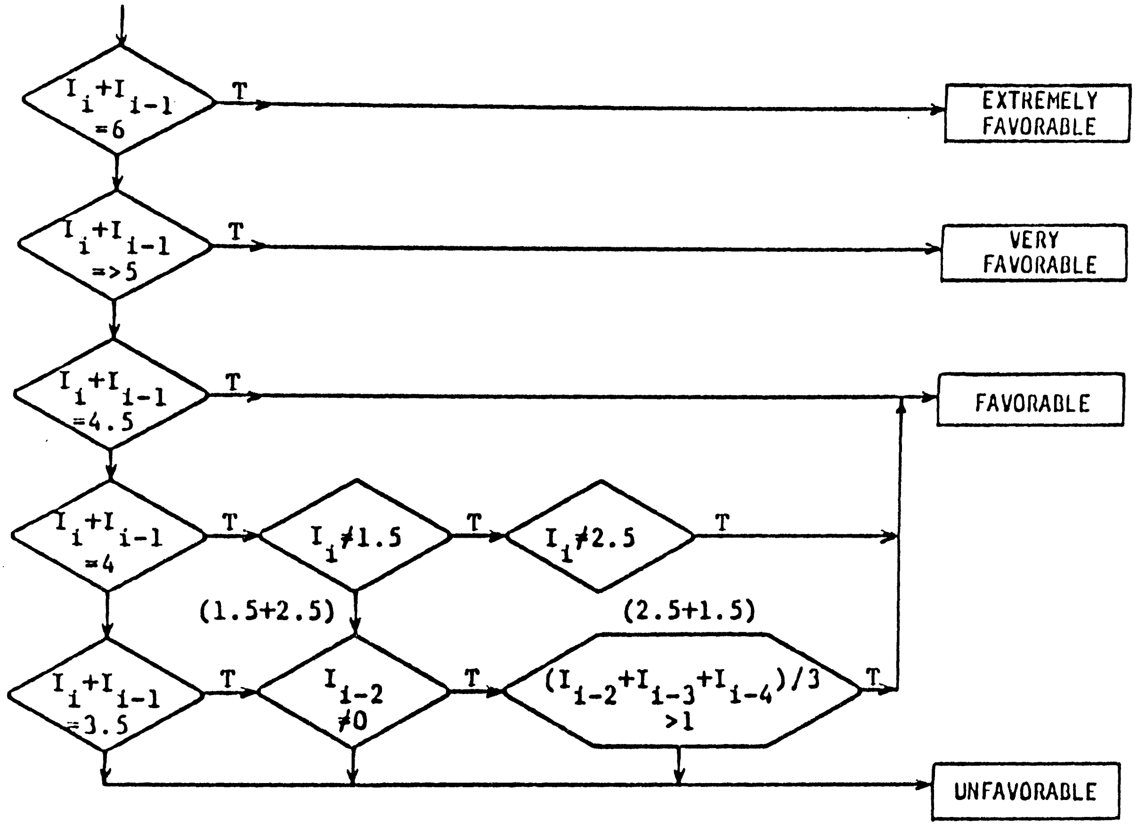

Figure 4. Model of the Virginia peanut leafspot advisory logic. Infection indices (I) for the past 5 days may be considered in the computation of an advisory with infection indices of the last two days (I_i and I_{i-1}) emphasized. (T = true)

APPENDIX B. FIELD DESCRIPTION AND MANAGEMENT PRACTICES IN 1985

A. Location 1

1. Location: Tidewater Agricultural Experiment Station (TAES)
   Holland Road: Suffolk, Virginia
2. Crop history: Corn, 1984; Peanut, 1983; Corn, 1982
3. Land preparation: moldboard plow and disk
4. Soil fertility report:
   - pH - 6.2
   - Ca - 576 ppm
   - Mg - 66 ppm
   - P - 27 ppm
   - K - 63 ppm
   - Zn - 0.7 ppm
   - Mn - 3.8 ppm

   Soil type - Dragston fine sandy loam
5. Nematode assay report (January 1985):

Nematode	Number/500cc soil
Stunt	40

6. Nematicide: Nemacur 15G, 13 lb/A (14 May)
7. Insecticide: Temik 15G, 7 lb/A (in furrow, 14 May)
   Sevin 80W, 1.25 lb/A (20 Jun)
   Dyfonate 20G, 10 lb/A (18 Jul)
   Lannate L, 1 pt/A (16 Aug)
8. Acaricide: Comite, 2 pt/A (12 Sep)
9. Herbicide:
   - Pre-plant - Vernam 10G, 25 lb/A (10 May)
   - Pre-emergence - Dyanap, 6 qt
     + Lasso 4E, 2 qt/A (17 May)
   - Post-emergence - Enide 50W, 4 lb/A (28 Jun)
10. Planting date and cultivar: 14 May 1985, Florigiant
11. Additional materials for crop management:
    a. Sclerotinia blight control:
       Rovral 50W, 2 lb/A (8 Jul, 26 Aug)
       Ronilan 50W, 1.5 lb/A (26 Jul)
    b. Landplaster, 400 lb/A (20 Jun)
    c. Cultivate (21 Jun)
    d. Tecmangam, 4 lb/A (28 Jun)
    e. Solubor, 1.25 lb/A (16 Jul)
    f. Kylar 80W, 0.5 lb/A (16 Jul)

B. Location 2

1. Location: TAES Research farm
   Hare Road: Suffolk, Virginia
2. Crop history: corn, 1984; peanut, 1983
3. Land preparation: moldboard plow and disk
4. Soil fertility report:
   - pH - 5.9
   - Ca - 276 ppm
   - Mg - 27 ppm
   - P - 49 ppm
   - K - 34 ppm
   - Zn - 0.5 ppm
   - Mn - 3.0 ppm

   Soil type - Kenansville loamy sand
5. Nematode assay report (January 1985):

Nematode	Number/500cc soil
Stunt	170
Spiral	10
Ring	50
Stubby root	10

6. Nematicide: Nemacur 15G, 13 lb/A (8 May)
7. Insecticide: Temik 15G, 7 lb/A (in furrow, 8 May)
   Dyfonate 20G, 10 lb/A (19 Jul)
   Lannate L, 1.5 pt/A (23 Aug)
8. Acaricide: Comite, 2 pt/A (19 Sep)
9. Herbicide:
   - Pre-plant - Vernam 10G, 25 lb/A (29 Apr)
   - Pre-emergence - Dyanap, 4 qt
     + Lasso 4E, 2 qt/A (9 May)
   - Post-emergence - Enide 50W, 4 lb/A (28 Jun)
10. Planting date and cultivar: 8 May 1985, Florigiant
11. Additional materials for crop management:
    a. Sclerotinia blight control:
       Rovral 50W, 2 lb/A (2 Aug, 26 Aug)
       Ronilan 50W, 1.5 lb/A (26 Jul)
    b. Landplaster, 900 lb/A (27 Jun)
    c. Cultivate (28 Jun)
    d. Solubor, 1.25 lb/A (16 Jul)
    e. Kylar 80W, 1 lb/A (16 Jul)

APPENDIX C. FIELD DESCRIPTION AND MANAGEMENT PRACTICES IN 1986

A. Location 1

1. Location: Tidewater Agricultural Experiment Station
   Holland Road: Suffolk, Virginia
2. Crop history: Corn, 1985; Peanut, 1984
3. Land preparation: moldboard plow and disk
4. Soil fertility report:
   - pH - 6.2
   - Ca - 522 ppm
   - Mg - 50 ppm
   - P - 37 ppm
   - K - 66 ppm
   - Zn - 0.6 ppm
   - Mn - 2.7 ppm

   Soil type - Dragston fine sandy loam
5. Nematode assay report (December 1985):

Nematode	Number/500cc soil	
Sample/	1	2
Root knot	10	30
Ring	80	140
Stunt	440	100

6. Nematicide: Furadan 15G, 13 lb/A (1 May)
7. Insecticide: Temik 15G, 7 lb/A (in furrow, 1 May)
   Sevin 50W, 2 lb/A (19 Jun)
   Dyfonate 20G, 10 lb/A (16 Jul)
   Lannate L, 1 pt/A (7 Aug, 15 Aug)
   Pydrin, 6 oz/A (22 Aug)
8. Herbicide:
   Pre-plant - Vernam 10G, 25 lb/A (1 May)
   Pre-emergence - Dyanap, 4 qt
   + Lasso 4E, 2 qt/A (9 May)
9. Planting date and cultivar: 1 May 1986, Florigiant
10. Additional materials for crop management:
    a. Sclerotinia blight control:
       Ronilan 50W, 1.5 lb/A (15 Jul, 15 Aug)
    b. Landplaster, 950 lb/A (27 Jun)
    c. Cultivate (9 Jun)
    d. Tecmangam, 4 lb/A (27 Jun, 5 Aug)

B. Location 2

1. Location: TAES Research Farm
   Hare Road: Suffolk, Virginia
2. Crop history: Corn, 1985; Peanut, 1984
3. Land preparation: moldboard plow and disk
4. Soil fertility report:
   - pH - 5.9
   - Ca - 216 ppm
   - Mg - 25 ppm
   - P - 42 ppm
   - K - 31 ppm
   - Zn - 0.5 ppm
   - Mn - 2.2 ppm

   Soil type - Kenansville loamy sand
5. Nematode assay report (December 1985):

Nematode	Number/500cc soil
Ring	180
Stunt	30

6. Cylindrocladium black rot management:
   Vapam, 20 gal/A (15 Apr)
7. Nematicide: Furadan 15G, 13 lb/A (8 May)
8. Insecticide: Temik 15G, 7 lb/A (in furrow, 8 May)
   Dyfonate 20G, 10 lb/A (17 Jul)
   Lannate L, 1 pt/A (7 Aug)
   Sevin 50W, 2 lb/A (18 Aug)
   Pydrin, 6 oz/A (22 Aug)
9. Herbicide:
   Pre-plant - Preemerge, 1 qt/A
   + Dual 8E, 1.5 pt/A (18 Apr)
   Pre-emergence - Dyanap, 4 qt
   + Lasso 4E, 2 qt/A (15 May)
10. Planting date and cultivar: 8 May 1986, Florigiant
11. Additional materials for crop management:
    a. Sclerotinia blight control:
       Ronilan 50W, 1.5 lb/A (15 Jul, 15 Aug)
    b. Landplaster, 850 lb/A (20 Jun)
    c. Cultivate (9 Jun)

APPENDIX D. PRECIPITATION RECORDS FOR FIELD LOCATIONS.

Table 1. Precipitation (in.) recorded daily at 1200 hours EST during June through September in 1985 at field location one (Tidewater Agricultural Experiment Station).

Day of month	June	July	August	September
1	0.00	0.11	0.00	0.00
2	0.00	0.00	0.29	0.00
3	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00
5	1.74	0.00	0.00	0.00
6	1.52	0.00	0.01	0.00
7	0.00	0.49	0.00	0.00
8	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00
10	0.00	0.02	0.00	0.00
11	0.00	2.11	0.00	0.00
12	0.02	0.00	0.00	0.00
13	0.89	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00
16	0.43	0.00	0.00	0.00
17	0.01	0.19	0.00	0.00
18	0.01	0.01	1.76	0.00
19	0.69	0.00	0.67	0.00
20	0.00	0.00	0.00	0.00
21	0.00	0.00	0.01	0.00
22	0.00	0.00	0.00	0.62
23	0.00	0.06	0.00	0.58
24	0.00	0.00	0.00	0.05
25	0.00	0.00	0.00	0.00
26	0.00	0.63	0.66	0.00
27	0.00	0.09	0.00	7.79
28	0.00	0.16	0.24	0.00
29	0.00	0.01	0.00	0.00
30	0.05	0.01	0.00	0.00
31	-	0.00	0.00	-
Total	5.36	3.89	3.64	9.04

Table 2. Precipitation (in.) recorded daily around 900 hours (EST) during June through September in 1985 at field location two (TAES Research Farm).

Day of month	June	July	August	September
1	0.00	0.09	0.00	0.00
2	0.00	0.50	0.34	0.00
3	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00
5	1.82	0.00	0.00	0.00
6	1.68	0.00	0.00	0.00
7	0.00	1.26	0.08	0.00
8	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00
10	0.00	0.03	0.00	0.00
11	0.00	2.09	0.06	0.00
12	0.58	0.00	0.00	0.00
13	0.88	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00
17	0.33	0.16	0.00	0.00
18	0.46	0.31	0.00	0.00
19	0.04	0.00	2.80	0.00
20	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00
23	0.00	0.10	0.00	1.18
24	0.00	0.00	0.00	0.06
25	0.00	0.00	0.00	0.00
26	0.00	0.53	0.73	0.00
27	0.00	0.00	0.00	7.06
28	0.00	0.00	0.32	0.00
29	0.00	0.19	0.00	0.00
30	0.00	0.00	0.13	0.00
31	-	0.00	0.00	-
Total	5.79	5.26	4.46	8.30

Table 3. Precipitation (in.) recorded daily at 1200 hours (EST) during June through September in 1986 at field location one (Tidewater Agricultural Experiment Station).

Day of month	June	July	August	September
1	0.00	0.26	0.02	0.00
2	0.04	0.01	0.00	0.00
3	0.01	0.01	0.26	0.08
4	0.00	0.00	0.01	0.00
5	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00
7	0.04	0.00	0.44	0.00
8	0.00	0.00	0.00	0.31
9	0.00	0.00	0.00	0.00
10	0.00	0.15	0.00	0.00
11	0.00	0.00	0.03	0.00
12	0.00	0.48	2.40	0.00
13	0.62	0.25	1.31	0.00
14	0.01	0.00	0.92	0.00
15	0.00	0.00	0.00	0.00
16	0.00	0.10	0.00	0.00
17	0.00	0.00	0.07	0.00
18	0.00	0.00	0.61	0.00
19	0.00	0.00	0.07	0.00
20	0.00	0.52	0.08	0.00
21	0.00	0.37	0.26	0.00
22	0.00	0.69	0.17	0.01
23	0.00	1.09	0.00	0.00
24	0.38	0.41	0.00	0.00
25	0.00	0.21	0.00	0.00
26	0.00	0.69	0.00	0.00
27	0.00	0.59	0.00	0.00
28	0.00	0.52	1.16	0.00
29	0.31	0.00	0.14	0.04
30	2.83	0.00	0.00	0.00
31	-	0.00	0.00	-
Total	4.24	6.35	7.95	0.44

Table 4. Precipitation (in.) recorded daily around 900 hours (EST) during June through September in 1986 at field location two (TAES Research Farm).

Day of month	June	July	August	September
1	0.00	0.40	0.00	0.00
2	0.00	0.00	0.00	0.03
3	0.00	0.00	0.15	0.05
4	0.00	0.00	0.03	0.00
5	0.00	0.00	0.00	0.00
6	0.08	0.00	0.00	0.00
7	0.00	0.00	0.42	0.00
8	0.00	0.00	0.00	0.50
9	0.00	0.00	0.00	0.00
10	0.00	0.09	0.00	0.00
11	0.00	0.00	0.07	0.00
12	0.00	0.46	1.35	0.00
13	0.81	0.24	0.88	0.00
14	0.00	0.00	0.50	0.00
15	0.00	0.00	0.00	0.00
16	0.00	0.15	0.00	0.00
17	0.00	0.00	0.00	0.00
18	0.00	0.00	0.76	0.00
19	0.00	0.00	0.05	0.00
20	0.00	0.30	0.06	0.00
21	0.00	0.66	0.50	0.00
22	0.00	0.03	0.50	0.00
23	0.00	0.46	0.00	0.00
24	0.15	0.24	0.00	0.00
25	0.00	0.26	0.00	0.00
26	0.00	0.42	0.00	0.00
27	0.00	1.23	0.00	0.00
28	0.00	0.84	1.00	0.00
29	0.93	0.00	0.34	0.00
30	3.25	0.00	0.00	0.00
31	-	0.00	0.00	-
Total	5.22	5.78	6.61	0.58

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