Special Report

Evolution of a Weather-Based Peanut Leaf Spot Spray Advisory in North Carolina

J. E. BAILEY, Department of Plant Pathology, North Carolina State University, Raleigh, 27695-7616; G. L. JOHNSON, Department of Horticulture Science, North Carolina State University, Raleigh 27695-7609; S. J. TOTH, JR., Department of Entomology, Box 7613, North Carolina State University, Raleigh, NC 27695-7613

ABSTRACT

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

A weather-based leaf spot spray "advisory" was deployed in North Carolina beginning in 1983 to help growers time fungicide applications to improve the management of early leaf spot (*Cercospora arachidicola*). Volunteer growers collected weather data that county extension staff used to compute spray advisories. In spite of the logistical difficulties in spraying according to a daily advisory, over 80% of peanut growers surveyed used these advisories in making spray decisions some, most, or all of the time. In an effort to give growers more time to respond to leaf spot spray recommendations, a method was developed to predict advisories 2 days in advance. These "forecast advisories" were relayed to county offices through an electronic mail system. Real time advisories fell within the estimated range of 2-day predicted advisories 71% of the time. It was concluded that these leaf spot spray advisories play an important role in the decision-making process for North Carolina farmers and that forecast advisories can be a useful tool in extending the time farmers have to respond to spray advisories.

Early leaf spot (*Cercospora arachidicola* Hori) is the principal foliar disease of peanuts in North Carolina, while late leaf spot (*Cercosporidium personatum*) is the predominant foliar disease in the southeastern states of Georgia, Florida, and Alabama. Crop rotation, partial resistance, and preventative fungicide sprays applied every 2 wk have been recommended as an effective, low risk leaf spot management program (1,20). In 1965, Jensen and Boyle (10,11) showed that peanut leaf spot occurrence is weather dependent and that environmental data could be used to predict disease onset. While they did not distinguish between the two leaf-spotting fungi, *C. arachidicola* was the predominant pathogen in Georgia at that time. Later, Parvin et al (16) formalized the rules of this empirical model and automated the system through computerization. It was in this work that an unambiguous algorithm, which defined the relationship between weather conditions and the need for fungicide applications, was developed. This peanut leaf spot advisory model (PLAM) has been used to time fungicide applications to coincide with disease-favorable weather (1,18).

In recent years, several workers have developed alternative methods of anticipating peanut leaf spot occurrence. A mechanistic approach which correlates temperature and humidity to growth components in the disease cycle of *C. arachidicola* promises improved disease management and reduced risk of yield loss as compared to the PLAM (5,6). An expert system, under development, considers both current and predicted weather events to determine the need for leaf spot sprays (7).

Some advisory models use fungicide spray records in addition to weather parameters to aid in determining when additional applications should be applied (5,7). Cu et al identified weather conditions lethal to *C. arachidicola* and adjusted disease-favorable index values accordingly (5). In addition, a fungicide half-life adjustment was included to allow for the different efficacies of various crop protection chemicals (5). Varietal resistance has also been used as a mitigating effect for a weather-based spray advisory (14).

Logistical problems have made successful deployment of spray advisory models to the farming community difficult. Efforts were made during the 1970s to use the PLAM to advise farmers in Georgia (16) and Texas (Horne et al, *personal communication*). However, the first widespread use by growers began in 1982 in Virginia (18). Investigations into the feasibility of using leaf spot advisories in North Carolina began in 1981. By 1983, leaf spot advisories were deployed (2). A telephone survey conducted in 1988, consisting of 31 randomly selected North Carolina farmers in one county with an active PLAM program, found that 52% of those polled used the advisory. An average of 2.4 sprays per year were avoided as a result of using the PLAM to time fungicide applications (Hitzig, *personal communication*). A survey of six North Carolina peanut counties conducted during 1989 showed that slightly more than half of 192 respondents relied on leaf spot advisories some or all of the time (Garber and Hoban, *personal communication*).

A significant problem with most disease advisory models is that they are not predictive (22). By the time disease-favorable weather conditions trigger a spray recommendation, the disease process is under way. Logistics of applying fungicides may further delay action for several more days. Consequently, fungicide efficacy can be reduced due to colonization of plant tissues by *C. arachidicola* prior to fungicide application. If disease-favorable weather patterns could be forecast 1 or 2 days in advance, fungicides could be applied prophylactically rather than after conditions favorable for leaf spot have already occurred. Efforts to forecast disease-favorable conditions have been used for several pathosystems (7,21,22).

The purpose of this paper is to 1) describe the method by which a peanut leaf spot advisory model was used by agricultural extension agents to advise growers in North Carolina; 2) describe a method of predicting 2 days in advance the cardinal weather parameters for the PLAM; and 3) discuss the level of acceptance of peanut leaf spot advisories by peanut growers in North Carolina.

MATERIALS AND METHODS

Simplification of the leaf spot advisory. Modifications were made to the Parvin et al (16) peanut leaf spot advisory model (PLAM) to make it easier to understand and use without computer assistance. A line was drawn to encompass 1.5 and 2.5 temperature/relative humidity index (T/RH) values on the Parvin et al (14) nomogram (Fig. 1) to reduce the ambiguity of these values for hand computation. Special cases in the original model, where up to 5 days of information was needed, were eliminated, resulting in a model that needed only 2 days of data.

Weather data collection for leaf spot advisories. Leaf spot advisories were deployed on a county-by-county basis. Data collection, analysis, and informa-

Present address of G. L. Johnson: USDA-ARS, N. W. Watershed Research Center, 800 Park Boulevard, Plaza 4, Suite 105, Boise, ID 83712-7716.

Accepted for publication 29 September 1993.

tion dissemination were coordinated by individual county agricultural extension agents. Two to five farms per county were selected as data collection sites in the northeastern peanut growing region of North Carolina. Volunteer growers utilized hygrothermographs to monitor temperature and relative humidity (RH) data on 7-day strip charts. Participants recorded the number of hours per 24 h when the RH was greater than or equal to 95%, and the minimum temperature during the high RH period each day. These two values were reported by phone to the local county extension office each day, which started and ended at 1200.

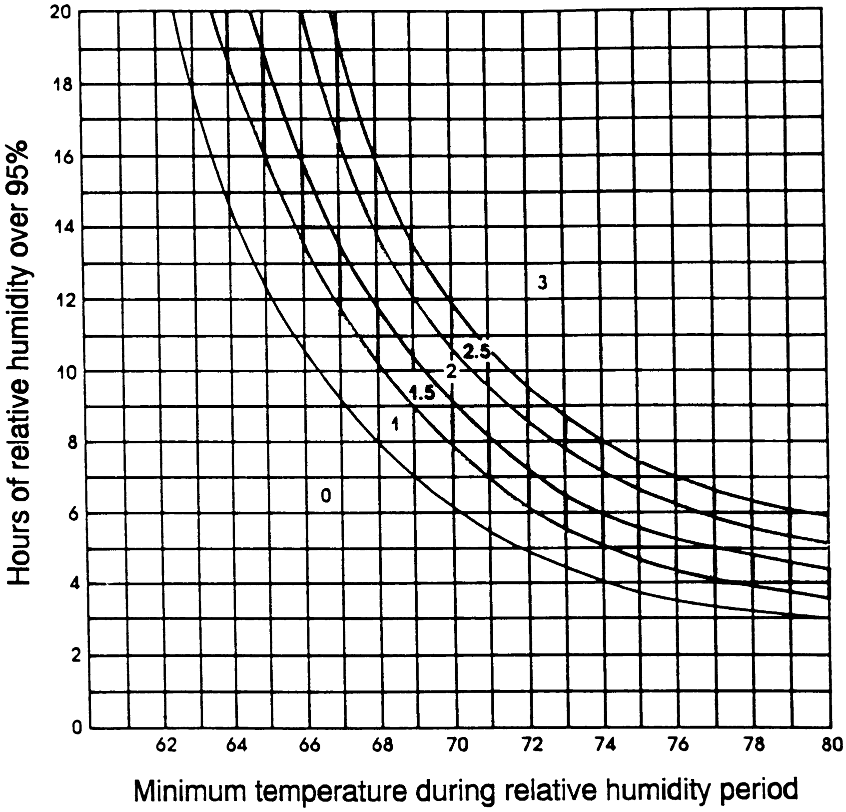
Forecast weather data. Meteorologists at the North Carolina Agricultural Weather Program, North Carolina State University, Raleigh, prepared an agricultural weather advisory by 0930 hours each day. This weather advisory included forecasts of maximum and minimum temperature, and number of hours with RH >80% at the standard weather shelter height (1.5 m) for each of the two succeeding 24-h periods. The 80% threshold value for high RH was chosen because it was found to correspond most closely to surface/plant canopy RH of 95%, which was the cardinal value for the PLAM (16). Rainfall predictions were not part of the agricultural weather advisory. However, agents were instructed to advise growers to spray before anticipated rain events (contained in National Weather Service [NWS] forecasts) if it had been 14 days or more since growers had last sprayed.

Peanut production in North Carolina primarily occurs in one NWS forecast zone (northern Coastal Plain), in which model output statistics (MOS) are not available. Algorithms were developed for calculating maximum and minimum air temperature and average dewpoint temperature at a reference station in this forecast zone (the Peanut Belt Agricultural Research Station, Lewiston, NC), derived from MOS forecasts of these parameters at the two nearest forecast points, Raleigh, North Carolina, and Norfolk, Virginia. Daily forecast values for these three parameters were computed from 21 June to 30 September 1990. Hourly temperature and RH values were estimated by fitting a sinusoidal wave to daytime (sunrise to sunset) temperatures, and an exponential curve to nighttime values (13,17). Dewpoint was assumed to be constant each night and represented an average of nighttime dewpoint values calculated from the MOS-based algorithm for the research station.

Minimum air temperature and hours of high (>80%) RH for each of the two succeeding 24-h periods (through 48 h) were generated for the peanut production zone. This information was included in the daily agricultural weather advisory. These values were used to determine the daily temperature/RH (T/RH) value (Fig. 1) which, when summed over a 2-day period, provided the necessary information to compute an advisory (Fig. 2).

Meteorologists preparing the advisory attached a range to each predicted value, expressing both the confidence in the forecast and the amount of spatial variability anticipated. A 3 C spread in forecast temperature and a 3-h range in forecast high RH hours was typical; however, ranges as high as 6 or 7 C (or hours) occurred on occasion when the forecast confidence was low.

Comparison of real and forecast T/RH index values. Real (R) and forecast (F) T/RH index values (Fig. 2) were compared from 21 June to 30 September 1990 over a wide array of weather conditions. Three T/RH index values were calculated each day; one using weather data from two consecutive days of temperatures and RH measured with a hygrothermograph (real plus real or 'RR'); one day measured with a hygrothermograph and one forecast day (real plus forecast or 'RF'); or two forecast days



Condition	Advisory
1. Sum of T/RH index values for last 2 days ≥ 3.5	Favorable (for disease development)
2. Sum of T/RH index values for last 2 days < 3.5	Unfavorable (for disease development)

Fig. 1. Modified nomograms (after Parvin et al [16]) for determining temperature/relative humidity (T/RH) index values. Temperature/relative himidity (T/RH) index values are indicative of the conduciveness of weather for leaf spot infection and spread where 0 is very unfavorable and 3 very favorable for disease occurrence.

Condition	Advisory
1. Sum of last two days' infection rate index numbers≥ 3.5	Favorable for disease development
2. Sum of last two days' infection rate index numbers ≤ 3.5	Unfavorable for disease development

Fig. 2. A simplification (after Parvin et al [16]) of the decision algorithm for calculation of spray advisories. Favorable conditions mean that conditions are conducive for disease development.

(forecast plus forecast or 'FF'). Two-day accrued T/RH index numbers ranged from 0 to 6 with 3.5 representing the threshold separating favorable and unfavorable weather conditions (Fig. 2).

Minimum and maximum T/RH index values were estimated for both RF and FF forecasts. The minimum T/RH index value was computed from the lowest estimated minimum nighttime temperature and the fewest estimated hours of high RH. Conversely, the maximum T/RH index value was based on the highest predicted minimum temperature and the longest estimated hours of high RH. Thus, the minimum expected value for a RF advisory was calculated using the measured T/RH index value for the previous 24 h and the minimum forecast T/RH value for the next 24 h. The minimum (Mn) FF T/RH index value consisted of the sum of the two minimum forecast T/RH index values for the two succeeding 24-h periods. In the same way, maximum (Mx) RF and FF expected T/RH values were calculated using maximum expected hours of high RH and temperature during the high RH period.

Table 1. Comparison of 2-day sums of temperature/relative humidity (T/RH) index values computed from forecast and measured weather data

Order of real and predicted T/H index[a] values	Forecast method					
	Frequency[b]		Expected[c] frequency		Percent[d]	
	RF	FF	RF	FF	RF	FF
RR < Mn < Mx[e]	13	8	10.5	10.5	22.03	13.56
Mn < RR < Mx	37	42	39.5	39.5	62.71	71.19
Mn < Mx < RR	9	9	9	9	15.25	15.25

[a] Temperature/relative humidity (T/RH) index values were computed as per Figure 1. RR = T/RH index values computed using 2 'real' (measured) days of data, Mn = the T/RH value computed using 2 days of the fewest hours of forecast wetting hour (high RH) and the minimum forecast temperature. Mx = the T/RH value from the maximum forecast temperature and longest hour of high RH. Forecast T/RH index values were predicted 1 or 2 days prior to the actual occurrence of the data.

[b] Values indicate the number of times each condition occurred (N = 59). RF = an accrued 2 day T/RH index value consisting of 1 measured real ('R') and one forecast ('F') day. FF = an accrued 2-day forecast T/RH index value computed from one and two day forecasts.

[c] Values represent the expected number of times each condition would occur if the RF and FF values were equally accurate. Chi-square analysis (21) showed no significant differences between the observed and expected frequencies (χ^2; df = 2, value = 1.507, $P = 0.471$) indicating that 1- and 2-day (RF and FF) forecast advisories were not significantly different from each other.

[d] Values represent the percentage of the time in which each condition occurred.

[e] RR < Mn < Mx represents an overestimate of the likelihood that a favorable advisory would be issued, Mn < Mx < RR is an underestimate. Mn < RR < Mx is the ideal condition where the actual 2-day accrued T/RH index values fell between the Mx and Mn forecast values.

1. Spray as soon as possible after conditions become favorable, but not within 14 days of last spray.

2. Try to spray preceding rain if it has been 14 days or more since last spray.

3. Scout all fields at least once a week, revert to 14-day schedule if any location in the field has over 20% leaf spot (one leaflet out of five with a spot).

4. If logistics prevent spraying within 3 days of the advisory, spray preventatively (14-day schedule).

5. If late leaf spot or web blotch is identified, revert to a 14-day spray schedule.

6. Growers should begin consulting the advisory on 20 June and spray when the first advisories are issued that conditions are favorable for disease development.

7. Chorothalonil is the leaf spot fungicide to use on the leaf spot advisory because of its broad spectrum of activity and effectiveness against early leaf spot.

8. Do not use chlorothalonil in fields with a history of sclerotinia blight.

9. Use leaf spot resistant varieties.

10. Rotate at least 2 years without peanuts.

Fig. 3. Guidelines for growers who participated in the leaf spot advisory program.

Growers' use survey. A survey was conducted to determine the degree to which growers were using leaf spot advisory information in North Carolina. A total of 503 growers in 10 counties, with 1,500 ha of peanuts or more, were surveyed by mail in May 1989. In these counties, 57,498 ha of peanuts were produced on 6,877 farms in 1988 (91% of the 1988 North Carolina harvest). Growers were randomly selected from mailing lists provided by the county Agricultural Stabilization and Conservation Service offices. The number of growers surveyed in each county was proportional to the peanuts and number of growers in the county. On 9 May 1990 the county extension agent mailed a cover letter, questionnaire, and business reply envelope to each peanut grower. On 16 May 1990, a follow-up letter from the agent was sent to each grower. On 30 May 1990 another letter, questionnaire, and business reply envelope were mailed to each grower not responding to the previous correspondence.

RESULTS

Accuracy of forecast leaf spot advisories. The variance (R^2) in maximum and minimum temperature and dewpoint explained by the forecasts (from 21 June through 30 September 1990) was quite high in summer conditions (0.82, 0.90, and 0.84, respectively). Index values were computed as follows: RF = an accrued 2-day T/RH index value consisting of 1 measured real ('R') and one forecast ('F') day, FF = an accrued 2-day forecast T/RH index value computed from 1- and 2-day forecasts. Frequency values (Table 1) indicate the number of times each condition occurred (N = 59). There was no significant difference (chi-squared value = 1.507; df = 2, $P = 0.471$) between RF and FF T/RH index values (Table 1).

Temperature/relative humidity (T/RH) index values were computed as indicated in Figure 1. RR = T/RH index values computed using two 'real' (measured) days of data, Mn = the T/RH value computed using two days of the fewest hours of forecast wetting hours (high RH) and the minimum forecast temperature, and MX = the T/RH index value from the most forecast wetting hours and the longest hour of high RH. Forecast T/RH index values were predicted 1 or 2 days prior to the actual occurrence of environmental conditions. RR < Mn < Mx represents an overestimate of the likelihood that a favorable advisory would be issued, Mn < Mx < RR is an underestimate. Mn < RR < Mx is the ideal condition where the actual 2-day accrued T/RH index values fell between the Mx and Mn forecast values. Frequency of the three possible conditions (i.e., RR < Mn < Mx, Mn < RR < Mx, or Mn < Mx < RR) were similar to the expected frequency. This indicated that advisories based on two 24-h forecasts may be as accurate as advisories containing one 24-h value of real information.

Using leaf spot advisories in county extension programs. Each day at noon, extension agents computed the real-time leaf spot advisory (RR) from hygrothermograph data collected by volunteer growers. Advisories were made available on a telephone recording in most participating counties. Growers were given guidelines for determining whether sprays were needed (Fig. 3). Videotapes, publications, and workshops were used to train county staff in the maintenance and use of hygrothermographs, computation of leaf spot advisories using the PLAM, and interpretation of weather forecast information relative to future advisories.

Maximum and minimum 2-day forecast (FF) T/RH index values were electronically mailed to the county offices each morning during the 1990 growing season (Fig. 4). Values between the two extremes were filled in with asterisks to indicate the range within which the real-time T/RH index values were expected to fall 2 days hence. These reports could be used by agricultural advisors to describe the predicted likelihood of disease-favorable weather. For example, if the current day's real-time T/RH index value was less than 3.5 (unfavorable for disease), and the 2-day forecast was as described in Figure 4A–C, then the following statements would be made, respectively: Figure 4A, "weather is unfavorable for leaf spot today, and the forecast indicates that weather conditions will remain unfavorable for the next 2-day period;" Figure 4B, "weather conditions are unfavorable today but may become favorable for disease the next 2 days", Figure 4C, "weather is unfavorable today, however, the forecast indicates conditions will become favorable in the next 2 days." The decision to apply fungicides was left to the grower and based on the guidelines in Figure 3.

Growers' survey. Results are presented for the six counties where an active advisory program was in place. A total of 151 growers responded in these six counties. Results indicated that 38% of the growers utilized the advisory most or all of the time, whereas 80% used the advisory some, most, or all of the time. Only 17% of growers who were aware of the advisory did not use it as part of their decision-making to schedule fungicide applications. Four percent of those surveyed were not aware of the leaf spot advisory program.

DISCUSSION

In the early 1980s, the concept of using weather information to aid in making leaf spot spray decisions was perceived by farmers, agricultural agents, and many applied researchers as rather abstract and too logistically complex for practical application. Increased risk of yield loss was feared by many users. These concerns were not without merit as many growers had only enough equipment and labor to spray their crop on a predictable 14-day spray schedule. This made rapid response to a favorable ("spray") advisory difficult. Research had shown that sprays applied according to the PLAM often resulted in more disease when compared to a 14-day spray schedule; however, yields were usually the same for both treatments (18). Another difficulty in North Carolina was that advisories needed to be issued each day but were not available on weekends and some holidays due to county agent work schedules. Even with these reservations, the popularity of this program in North Carolina grew steadily from its introduction in 1983 (Hitzig, *personal communication*). By 1990, more than 80% of the peanut growers surveyed said they were using advisories in making spray decisions some, most, or all of the time. The degree to which they followed the strict guidelines of the program was not known. However, it appeared that the method of utilization was a continuum from nonparticipants to those who followed the "letter of the law."

Not all counties accepted the use of a spray advisory program. Some agents declined to participate, while others have tried with only limited grower acceptance. The primary reasons for these "failures" were the unwillingness of some growers to adopt a more logistically complex and risky spray schedule. In addition, those counties with a concentration of tobacco production have growers with major labor commitments during the time when fungicide sprays are needed. This makes it more difficult to participate in a spray program that requires a great deal of work flexibility. Growers sometimes had difficulty with the logistics of growing multiple crops and following a weather-based spray schedule. As a

```
Estimated Leaf Spot Advisory for Periquimans County
(for 8 July 1990)
A.
**********************
|-------------------------------------------------------<   >---------------------------------------|
0               1                2              3    <3.5>    4             5              6
                  < = Unfavorable                             Favorable = >
B.
                                               ******************
|-------------------------------------------------------<   >---------------------------------------|
0               1                2              3    <3.5>    4             5              6
                  < = Unfavorable                             Favorable = >
C.
                                                              *********************
|-------------------------------------------------------<   >---------------------------------------|
0               1                2              3    <3.5>    4             5              6
                  < = Unfavorable                             Favorable = >

** = range of possible advisories
```

Fig. 4. Typical peanut leaf spot advisories forecast sent 2 days before the target date from North Carolina State University campus to peanut county extension offices via electronic mail. **(A)** Unfavorable forecast advisory. **(B)** Forecast advisory which may or may not be favorable. **(C)** Favorable forecast advisory. Two-day forecast advisories (FF) were used exclusively during the summer of 1990. The asterisks on the far left of each advisory represents the minimum and the right side the maximum expected 2-day forecast accrued T/RH index values expected. The asterisks in between represent the anticipated range in which the real advisory will fall 2 days hence.

result, if farm managers were unable to spray within 3 days of a favorable advisory, it was recommended that a calendar-based spray program be used instead of the advisory.

The overall success of the advisory appears to be attributable to several factors. Early leaf spot (*C. arachidicola*) of peanut is the predominant foliar disease in North Carolina and, consequently, use of a single disease predictive system increases only slightly the risk of a secondary disease epidemic. Growers realize that leaf spot pressure varies from year to year and understand that weather conditions play a major role in this variation. The majority of growers probably did not spray on a strict 14-day schedule even in the absence of a leaf spot spray advisory. Also, pressure to reduce fixed costs in production make the reduction of unnecessary expenses desirable. As a result, many growers want as much information as possible regarding when to spray. Another important factor was the increase in acceptance of the Virginia leaf spot advisory program, which received daily radio exposure. This raised awareness of many North Carolina growers in counties that border Virginia as to the potential benefits of an advisory system.

Unlike Virginia, which had several remotely monitored regional weather stations, North Carolina had no suitable weather monitoring sites in the major peanut-growing area. The pilot leaf spot advisory program in Texas (Horne et al, *personal communication*) in 1976 was used as the model for the development of leaf spot advisories in North Carolina. Many field demonstrations, tours, county meetings, videotapes, and publications were developed to educate the agents and growers regarding the use of hygrothermographs, advisory issuance, and the principles and limitations of advisories. Hygrothermograph charts were confusing to many lay volunteers. Agents had to accept as part of their coordinating effort the quality control of weather data.

Guidelines were adopted to aid growers in determining whether or when to spray. Many of these rules were originally developed in Virginia (18). Growers were told to spray as soon as possible after conditions became favorable, but not within 14 days of the last spray, since it was assumed that fungicide protection would last approximately that long (4,12,20). If rain was imminent, growers were advised to spray before the rain event. Fungicide applied before a rain event was washed off the leaf to some degree (4); however, protection during disease favorable rainy periods was critical to efficacious disease control.

It was recommended that all fields be scouted at least once per week. Scouting was used to assure that early leaf spot control was adequate and that other, more difficult to control diseases such as late leaf spot (*C. personatum*) or web blotch (*Phoma arachidicola*) did not become a problem.

Growers were advised to begin following the advisory on 20 June. Historically, this period occurs before leaf spot epidemics are observed in North Carolina. It would be preferable in the future to use a phenological starting data such as the one proposed by Cu et al (5) in conjunction with a weather-based disease advisory.

Chlorothalonil was the fungicide recommended for use with the PLAM because it is the most effective material for control of early leaf spot and other secondary foliar diseases of peanut (20). One exception to recommending the use of chlorothalonil was when fields had a history of sclerotinia blight (*Sclerotinia minor* Jagger). Chlorothalonil causes an increase in the severity of this disease (8). As a result, growers were advised to use another leaf spot fungicide. It is likely that reduced vine damage, due to fewer fungicide applications applied using the advisory, also helped to keep sclerotinia blight and rhizoctonia incidence low (3,8,19). The yield-altering effects of soil compaction may also be reduced (15).

Forecast T/RH index values proved to be useful in anticipating leaf spot advisories 1 and 2 days in advance. Two-day forecasts were more desirable than 1 day since they allowed one additional day of warning.

Minimum (Mn) and maximum (Mx) predicted T/RH index values were designed to estimate the least and greatest likely T/RH value that would occur when measured on the forecast date (2-day forecast = 2 days hence). Ideally, T/RH real index values computed from hygrothermographs (RR) should have been bracketed between Mn and Mx 2-day values forecast 2 days earlier (i.e., Mn < RR < Mx). This would indicate that the forecast estimates were accurately estimating the range of values within which the measured (real) value would fall. This also would allow agricultural advisors to give unambiguous recommendations when the forecast 2-day accrued index values (FF) were too low (Mx < 3.5) for a favorable advisory, or too high (Mn > 3.5) for an unfavorable advisory.

Although 2-day T/RH index values (FF) correctly bracketed the real values (RR) 71% of the time, two types of errors occurred when, 1) the predicted Mn T/RH index value was greater than RR, or 2) Mx was less than the RR. The first type of error was indicative of a more disease-favorable weather forecast than actually occurred, resulting in an erroneous forecast favorable (spray) unfavorable (no spray) recommendation. The second error type resulted in a false no-spray recommendation.

Underestimating the likelihood of favorable weather conditions was the most hazardous type of error. Potentially, growers might not spray when it was needed. However, because real-time advisories (RR) were subsequently issued, recovery was possible if rains did not interfere. Growers were advised to spray if rains were likely, so the chance of this error occurring was reduced.

Electronic mail delivery of the forecast T/RH index values was a convenient and timely method of deploying this information. This information was delivered to participating counties in 1990 only, due to subsequent limitations of funding and personnel. Consequently, county agricultural agents did not have the opportunity to use this information long enough to make it an integral part of their programs.

Future goals with regard to forecast advisories include automated extraction of MOS variables and generation of 2-day forecasts for the peanut production zone, and better specifications of nighttime dewpoint using other methods. The replacement of manual, subjective methods for specifying ranges of temperature and high hours of RH with a probabilistic model will also be investigated. Finally, replacing the current NWS limited-area fine mesh (LFM) model with the new, nested grid model (NGM) to derive MOS values should improve both temperature and dewpoint forecasts (9), and, ultimately, leaf spot advisory predictions.

ACKNOWLEDGMENTS

We thank E. Barclay for data entry and analysis of hygrothermograph data, J. Smith and D. Dickie for statistical analysis and consultation, and the North Carolina Peanut Growers Association for partial funding of this work.

LITERATURE CITED

1. Bailey, J. E. 1992. Peanut disease control. Pages 82-96 in: 1992 Peanuts. Agric. Ext. Serv., North Carolina State University. Publication AG-331. 111 pp.
2. Bailey, J. E., Hitzig, R., and Johnson, G. L. 1989. Progress in the use of leaf spot advisories in North Carolina. (Abstr.) Proc. Am. Peanut Res. Educ. Soc. 21:25.
3. Brenneman, T. B., and Sumner, D. R. 1990. Effects of tractor traffic and chlorothalonil applied via ground sprays or center pivot irrigation systems on peanut diseases and pod yields. Plant Dis. 74:277-279.
4. Bruhn, J. A., and Fry, W. E. 1982. A mathematical model of the spacial and temporal dynamics of chlorothalonil residues on potato foliage. Phytopathology 72:1306-1312.
5. Cu, R. M., Phipps, P. M., and Stipes, R. J. 1989. A new advisory model for fungicide application to control early leaf spot of peanut in Virginia. Proc. Am. Peanut Res. Educ. Soc. 21:16.
6. Cu, R. M., Phipps, P. M., and Stipes, R. J. 1990. The effect of fungicide and cultivar selection on performance of the Virginia Peanut Leaf spot Advisory Program. Proc. Am. Peanut Res. Educ. Soc. 22:23.
7. Davis, D. P., Jacobi, J. C., and Backman, P. A. 1991. AU-Pnuts leaf spot advisory validation studies. Proc. Am. Peanut Res. Educ. Soc. 23:61.
8. Hau, F. C., and Beute, M. K. 1983. Effects of chlorothalonil on the virulence and physiology of a nontargeted pathogen, *Sclerotinia minor.*

Phytopathology 73:475-479.
9. Jacks, E., Bower, J. B., Dagostaro, V. J., Dallavalle, J. P., Erickson, M. C., and Su, J. C. 1990. New NGM-based MOS guidance for maximum/minimum temperature, probability of precipitation, cloud amount, and surface wind. Weath. Forecast. 5:128-138.
10. Jensen, R. E., and Boyle, L. W. 1965. The effect of temperature, relative humidity and precipitation on peanut leaf spot. Plant Dis. Rep. 49:975-978.
11. Jensen, R. E., and Boyle, L. W. 1966. A technique for forecasting leaf spot of peanuts. Plant Dis. Rep. 50:810-814.
12. Knudsen, G. R., Johnson, C. S., and Spurr, H. W. 1988. Use of a stimulation model to explore fungicide strategies for control of Cercospora leaf spot of peanut. Peanut Sci. 15:39-43.
13. Linvill, D. E. 1990. Calculating chilling hours and chill units from daily maximum and minimum temperature observations. HortScience 25:14-16.
14. Matyac, C. A., and Bailey, J. E. 1988. Modification of the peanut leaf spot advisory for use on genotypes with partial resistance. Phytopathology 78:640-644.
15. Mozingo, R. W. 1981. Effect of cultivars and field traffic on fruiting patterns of Virginia type peanuts. Peanut Sci. 8:103-105.
16. Parvin, D. W., Smith, D. H., and Crosby, F. L. 1974. Development and evaluation of a computerized forecasting method for Cercospora leaf spot of peanuts. Phytopathology 64:385-388.
17. Perry, K. B., Wehner, T. C., and Perry, K. B. 1986. Comparisons of fourteen methods to determine heat unit requirements for cucumber harvest. HortScience 21:419-423.
18. Phipps, P. M., and Powell, N. L. 1984. Evaluation of criteria for the utilization of peanut leaf spot advisories in Virginia. Phytopathology 74:1189-1193.
19. Porter, D. M., and Powell, N. C. 1978. Sclerotinia blight development in peanut vines injured by tractor tires. Peanut Sci. 5:87-90.
20. Smith, D. H., and Littrell, R. H. 1980. Management of peanut foliar diseases with fungicides. Plant Dis. 64:356-361.
21. Wilks, D. S., Rapose, R., and Fry, W. E. 1989. Modeling use of MOS-based relative humidity duration forecasts for management of potato late blight. Preprints, 19th Conf. on Agric. and Forest Met., Charleston, SC. Am. Meteor. Soc. Pages 67-69.
22. Wilks, D. S., and Shen, K. W. 1991. Threshold relative humidity duration forecasts for plant disease protection. J. Appl. Met. 30:463-477.