CHAPTER 3. THE EFFECT OF PLANTING DATE ON SCLEROTINIA BLIGHT OF PEANUT AND PERFORMANCE OF ALGORITHMS FOR FUNGICIDE APPLICATION

ABSTRACT

The effect of planting date and fungicide use patterns on Sclerotinia blight of peanut was determined in field trials at the Tidewater Agricultural Research and Extension Center in Suffolk, Virginia, from 1994 through 1997. Peanuts were planted ca. 8-14 days apart beginning ca. 20 April and ending ca. 20 May. Later planting significantly reduced seasonal plant growth and delayed the occurrence of peanut growth stages. Fungicide treatments were significant each year for disease incidence at harvest (DIH), area under the disease progress curve (AUDPC), and yield, while the effect of planting date was significant for AUDPC in 1995, DIH and AUDPC in 1996, and yield in 1997. Reduced plant growth delayed disease onset and significantly reduced early season levels of disease in the late planted peanuts (20 to 28 May) in 1995, 1996, and 1997. However, later planting did not result in a significant yield increase in any year. In 1994, fluazinam applied according to the original FDI 32 algorithm significantly reduced the DIH and AUDPC while improving yield when compared to demand applications. The original FDI 32 algorithm performed as well as the demand program with sprays of fluazianm and iprodione in 1995. Algorithms with adjusted thresholds according to days after planting (DAP) and algorithms with modified indices for vine growth and temperature significantly improved fungicide performance when compared to the original FDI 32 algorithm and performed as well as the demand program in 1996 and 1997 when fluazinam (0.58 kg a. i./ha) was used. Iprodione (1.12 kg/ha) significantly improved yield when applied according to the demand program in 1997. Data presented in this study indicate that planting date is not a dependable disease management tool. The results also indicate that algorithms using DAP-dependent FDI thresholds and modified indices for vine growth and air/soil temperature show the greatest potential for improving the efficiency of fungicide sprays.

INTRODUCTION

Sclerotinia blight, caused by *Sclerotinia minor* Jagger, is the most destructive disease of peanut in Virginia, Oklahoma, northeastern North Carolina and Texas (17, 19, 24, 27, 28). Current control recommendations such as cultivar selection, crop rotation, sanitation and fungicide application provide some disease suppression, but significant yield losses still occur when environmental conditions are favorable for the disease .

Fungicide treatments have been shown to offer the most consistent method for control of Sclerotinia blight. Current recommendations call for application of iprodione [3-(3,5-dichlorophenyl)-N-(methylethyl)-2,4-dioxo-1-imidazolidine carboximide] at the initial onset of disease, more commonly referred to as "demand", which requires intensive scouting for early detection of disease (15). Depending on the time of disease onset and disease pressure, two or three sprays may be applied at 3 to 4-wk intervals subsequent to the initial fungicide application. Iprodione applied at 1.12 kg a.i/ha provided 31% suppression of disease incidence and increased yield by 718 kg/ha over a 4-yr period in replicated field trials (23). Similar applications of the experimental fungicide, fluazinam [3-chloro-N-(3-chloro-5-trifluoromethyl-2-pyridyl)-2,2,2-trifluoro-2,6-dinitro-p-toluidine] at 0.56 kg a.i/ha, resulted in 69% suppression of disease incidence and increased yield by 1598 kg/ha.

Environmental factors such as moisture and soil temperature as well as host growth and canopy development have long been implicated as being important determinants in outbreaks of Sclerotinia blight of peanut (1, 6, 7, 8, 20). Results from a 16-yr study concluded that vine growth and rainfall were the primary determinants for eliciting the onset of Sclerotinia blight in southeastern Virginia (13). This research has provided the fundamental knowledge for constructing algorithms to improve the timing of fungicide application for disease control (14).

Host age has also been implicated in contributing to the onset and severity of diseases caused by *Sclerotinia* spp. Dow et al. (6) reported that infection by *S. minor* was greater in 8-wk old peanut plants than in 16-wk old plants. Brune (4) found similar results with Sclerotinia crown and stem rot of alfalfa (SCSR) in that 2-wk old plants were severely affected by SCSR, whereas 8-wk old plants showed a marked decrease in disease severity. Lesions were smaller on older, basal parts of detached peanut stems inoculated with *S. minor* than on younger, terminal segments of stems (3). Field studies conducted on SCSR of alfalfa demonstrated that the risk of severe disease losses can be greatly reduced if plant stands reach 10-wk of age prior to the emergence of apothecia of *Sclerotinia trifoliorum* Eriks (25).

The objectives of this research were 1) to assess the role of host and environmental parameters in the onset and severity of Sclerotinia blight of peanut, 2) to evaluate the effect of planting date on disease development, and 3) to test the performance of algorithms in predicting disease onset and the need for fungicide treatments. The data collected are expected to enable validation or improvement of current algorithms for fungicide application, and provide insight for integration of disease-suppressive cultural practices into disease management.

MATERIALS AND METHODS

Field trials were planted to the cultivars NC 9 in 1994, NC-V 11 in 1995, and VA-C 92R in 1996 and 1997. Corn and peanut were rotated in adjacent sections of a field each year to allow placement of peanut trials in a 2-yr rotation, which is a common practice in Virginia. Both sections of the field were a Nansemond fine sandy loam that was naturally infested with *S. minor* and had a history of severe losses to Sclerotinia blight of peanut. Four planting dates were spaced ca. 8-14 days apart as follows: April 20, April 30, May 10 and May 20 in 1994; April 20, May 1, May 9 and May 22 in 1995; April 19, May 1, May 9 and May 23 in 1996; and April 21, May 5, May 15 and May 28 in 1997. Hereafter, 19 April to 21 April plantings will be referred to as plant date I; 30 April to 5 May plantings as plant date II; 9 May to 15 May plantings as plant date III; and 20 May to 28 May as plant date IV. Except for fungicide inputs for control of Sclerotinia blight, each planting was managed according to standard practices for peanut production in Virginia (26). Chlorothalonil at 1.26 kg a. i./ha was used for control of early leaf spot according to the Virginia leaf spot advisory program (5). The experimental design consisted of a randomized complete block with planting dates as the main plots and fungicide treatments in subplots of four rows measuring 10.7 m in 1995 and 1997, and 9.1 m in 1994, and 10.4 m in 1996. Row spacing was 0.91-m for each year. Fungicide sprays were applied to the two center rows of each plot while adjacent outside rows served as buffers (16). Sprays were applied with one, 8010LP nozzle centered over each row at a height to provide complete coverage of plants. Output was calibrated to deliver 374 L/ha at 234 kPa and a ground speed of 6.28 km/hr.

Subsequent to emergence, the progress of plant growth and development was monitored in all plantings according to the descriptions by Boote et al. (2). Measurements of the mainstem and distance between vines in adjacent rows were recorded at ca. 2-wk intervals. Vine growth and canopy development were evaluated weekly to assign the host indices which are components of the original FDI algorithm for the Virginia Sclerotinia blight advisory (14). Growth indices of one or two were assigned when vines were >15 cm or ≤15 cm from touching between rows, respectively. A growth index of three was assigned after vines were overlapping between rows. Foliar canopy indices of one, two or three were given when <75, ≥75, or ≥95% of the soil surface was shaded, respectively.

Environmental indices used by the original FDI algorithm included rainfall, relative humidity, air temperature and soil temperature at the 10 cm depth. A moisture index of one was assigned if accumulated rainfall was ≥1.27 cm in the previous 5 days, ≥2.54 cm in the previous 10 days, or periods of RH≥95% were ≥8 hr the previous day. Temperature indices were three, two or one when daily soil temperature averages were ≤22, 23-25 or 26-28 C, respectively. Environmental conditions not within these parameters were assigned an index of zero. A 5-day index (FDI) of risk was developed by multiplying the host and environmental indices for a given day, then summing daily indices of the preceding 5 days. Tests in 1994 and 1995 utilized the original FDI algorithm with a threshold of 32 for fungicide application. In 1996 and 1997, the original FDI algorithm was tested with FDI thresholds that varied according to days after planting (DAP). This approach to determining the timing of fungicide application was expected to compensate for the increased susceptibility of younger plants, and hereafter is referred to as DAP-dependent threshold algorithm. DAP-dependent threshold levels were: FDI=16 at ≤90 DAP, FDI=32 at 91-120 DAP, and FDI=64 at >120 DAP. Studies after 1995, also included a modified vine index which used growth indices of one or two when vines were >30 cm or ≤30 cm from touching between rows, respectively, and index values of three or four when vines were ≤15 cm from touching or when vines were overlapping between rows, respectively. This was coupled with a new air-soil temperature index which used the temperature source which resulted in the highest risk index. This new algorithm utilized the DAP-dependent thresholds for fungicide application and is hereafter referred to as the mod. vine/air-soil temp. threshold algorithm with DAP-dependent thresholds.

Field plots were scouted at least weekly beginning in mid-June for early detection of disease. Once disease onset was detected, disease incidence was recorded every 2-wk as the number of infection foci in the two center rows of each plot. An infection focus exhibited symptoms and/or signs of Sclerotinia blight and included 30.5 cm of row length. Disease incidence data over the growing season were used to calculate area under the disease progress curve (AUDPC) using the procedure reported by Shaner and Finney (22). Yield was assessed by combining the two center rows of each plot and whole pod weights were adjusted to 7% moisture (w/w). All planting dates were inverted (dug) at the same time at the end of the season. Analysis of plant growth measurements, disease incidence at harvest (DIH), area under the disease progress curve (AUDPC), and yield utilized the Waller-Duncan *k*-ratio *t* test at $P \leq 0.05$ (SAS Institute, Inc., Cary, NC). The significance of planting date (main plots) and fungicide treatments (subplots) was determined by a split-plot analysis ($P \leq 0.05$).

Microsoft Excel® was used to maintain data records, calculate disease risk (FDI), and determine the timing of fungicide applications for each treatment. Environmental data were collected by a Virginia Tech/USDA agro-environmental monitor (21) in 1994 and 1995 and an Envirocaster® (Neogen Corp., Lansing, MI) in 1996 and 1997. Both weather stations monitored daily rainfall and recorded hourly averages of air temperature, soil temperature, dew point and RH.

RESULTS

1994 Field Tests. In 1994, near optimum growing conditions resulted in the state average yield being only 39 kg/ha below the record. Disease onset occurred on 3 August which was subsequent to row closure in all plant dates and following ca. 15 cm of rainfall between 17 and 27 July. Disease progressed rapidly due to favorable conditions which prevailed from the time of onset until harvest (Fig. 5). At the time of disease onset, plant growth was similar in all planting dates due to the relatively late onset of disease (Table 6).

According to a split-plot analysis, the effect of planting date was not significant for 1994 and there was no interaction between planting date and treatment (Table 7). This permitted the effect of fungicide spray programs to be averaged across planting dates. Significant effects for fungicide programs were detected for DIH, AUDPC, and yield. All spray programs in 1994 called for two fungicide applications. Fluazinam applied according to the original FDI 32 algorithm resulted in significantly lower DIH and AUDPC, and significantly higher yields when compared to the demand program in 1994 (Table 8). When compared to the untreated check, demand applications of iprodione significantly reduced DIH while sprays applied according to the original FDI 32 algorithm and the demand program significantly reduced the AUDPC in 1994.

1995 Field Tests. The growing season for 1995 was hot and dry with rainfall accumulations 12.1 cm below normal (May-September). However, rainfall in May and June was 2.9 and 2.3 cm above normal, respectively. Disease onset occurred in plant dates I, II, and III on 4 July after 4.9 cm of rainfall accumulation from the previous 10 days. At this time, peanuts had already begun flowering and vines in adjacent rows were near 25.9, 29.7, and 28.4 cm from touching between rows, respectively (Tables 6 and 9). Disease progress for plant dates I, II, and III was static from late July to mid-September due to environmental conditions being unfavorable for disease development (Fig. 5). Disease progressed to an average of 39 foci/plot in plant dates I, II, and III just prior to harvest. Plant date IV contained plants with significantly less growth than the earlier plant dates on 4 July, which resulted in disease onset being delayed until 16 July. At this time, vines in adjacent rows had

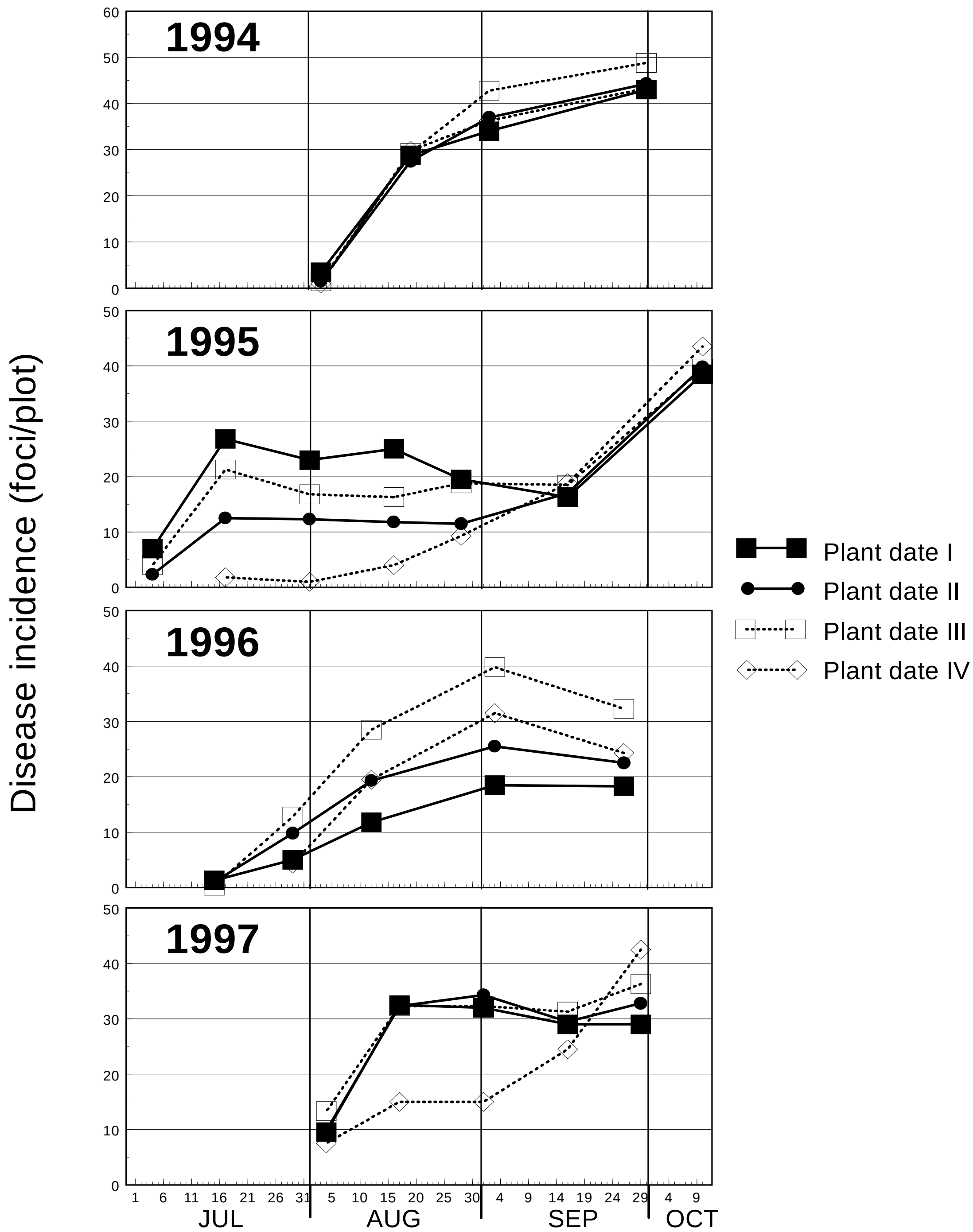

Figure 5. Effect of planting date on the onset and progress of Sclerotinia blight of peanut.

Table 6. Effect of planting date on vegetative growth of peanut (1994-1997).

Year, plant measurement and planting date[1]	Sampling dates					
	15 Jun	1 Jul	13 Jul	27 Jul	10 Aug	31 Aug
1994						
Mainstem height (cm)[2]						
I. April 20	7.1 a	15.5 b	14.7 a	24.9 a	29.5 a	37.8 a
II. April 30	6.4 ab	17.0 a	16.3 a	23.6 a	27.4 a	40.4 a
III. May 10	5.8 ab	14.2 c	14.4 a	24.6 a	27.9 a	33.5 a
IV. May 20	5.6 b	13.5 c	15.0 a	23.1 a	29.2 a	35.8 a
Lateral limb length (cm)[2]						
I. April 20	8.6 a	17.3 a	24.1 a	28.7 a	29.7 a	70.5 a
II. April 30	7.8 ab	16.5 a	18.5 a	27.4 a	30.7 a	59.7 ab
III. May 10	6.1 b	12.2 b	18.0 a	24.4 a	28.2 a	55.0 b
IV. May 20	6.1 b	12.9 b	21.3 a	22.8 a	31.0 a	64.3 ab
1995	Jun 16	Jun 30	Jul 15	Jul 28	Aug 11	Aug 21
Mainstem height (cm)[2]						
I. April 20	8.4 a	16.3 b	31.8 a	33.0 a	37.6 a	40.0 a
II. May 1	6.6 c	15.2 b	29.0 b	31.0 b	34.3 b	39.1 a
III. May 9	7.1 b	17.5 a	30.0 c	34.0 a	37.6 a	40.6 a
IV. May 22	5.1 d	11.4 c	20.6 d	26.2 c	30.0 c	34.5 b
Distance between vines in adjacent rows (cm)[3]						
I. April 20	59.4 c	25.9 c	0.0 b	0.0 a	0.0 a	0.0 a
II. May 1	67.6 b	29.7 b	0.0 b	0.0 a	0.0 a	0.0 a
III. May 9	67.3 b	28.4 c	0.0 b	0.0 a	0.0 a	0.0 a
IV. May 22	79.8 a	51.0 a	11.8 a	0.0 a	0.0 a	0.0 a

Table 6. Continued.

Year, plant measurement, and planting date[1]	Sampling dates					
	17 Jun	27 Jun	5 Jul	19 Jul	24 Jul	11 Aug
1996						
Mainstem height (cm)[2]						
I. April 19	9.3 a	11.4 a	13.0 ab	17.0 b	19.5 b	20.7 c
II. May 1	8.1 b	10.6 b	12.3 b	16.7 b	19.9 b	22.0 b
III. May 9	7.9 b	9.9 c	13.6 a	19.5 a	22.4 a	28.5 a
IV. May 23	5.9 c	8.0 d	10.8 c	15.9 c	17.7 c	21.5 bc
Distance between vines in adjacent rows (cm)[3]						
I. April 19	57.2 d	35.3 c	28.4 c	6.4 b	1.8 c	0.0 a
II. May 1	63.0 c	43.2 b	30.5 c	8.9 b	4.8 b	0.0 a
III. May 9	66.5 b	46.2 b	35.5 b	6.6 b	3.0 bc	0.0 a
IV. May 23	75.4 a	59.7 a	48.3 a	15.0 a	8.9 a	0.0 a
1997	19 Jun	29 Jun	7 Jul	14 Jul	28 Jul	13 Aug
Mainstem height (cm)						
I. April 21	6.4 a	8.1 a	9.9 a	12.7 a	25.2 a	28.4 a
II. May 5	5.4 b	7.2 b	8.6 b	10.6 c	22.9 b	26.8 b
III. May 15	5.2 b	7.0 b	8.6 b	11.5 b	24.0 b	27.3 ab
IV. May 28	3.2 c	5.3 c	7.0 c	9.6 d	21.5 c	25.1 c
Distance between vines in adjacent rows (cm)						
I. April 21	71.8 d	64.5 c	55.1 c	42.7 b	11.1 b	0.8 ab
II. May 5	75.4 c	66.3 b	57.7 b	45.5 b	11.4 b	0.0 b
III. May 15	76.9 b	67.6 b	58.4 b	46.2 b	12.2 b	1.3 ab
IV. May 28	82.5 a	70.4 a	64.5 a	53.3 a	18.8 a	3.3 a

[1] Means followed by the same letter(s) and within plant date are not significantly different at $P \leq 0.05$ according to the Waller-Duncan *k*-ratio *t* test.

[2] Mainstem and lateral limb measurements were assessed from two randomly selected plants in each of the two center rows of each plot.

[3] Measurements were the distance between vines in adjacent rows of both ends of the two center plot rows.

Table 7. Effect of planting date on disease incidence at harvest (DIH), area under the disease progress curve (AUDPC), and pod yield of peanut[1].

Year and planting date	DIH[2]		AUDPC		Yield (kg/ha)[3]	
1994						
I. April 20	43.0	a	1506	a	1650	a
II. April 30	44.3	a	1571	a	1585	a
III. May 10	48.8	a	1763	a	1487	a
IV. May 20	43.3	a	1568	a	1732	a
1995						
I. April 20	38.5	a	2197	a	2552	a
II. May 1	39.8	a	1534	ab	2739	a
III. May 9	39.5	a	1870	ab	2461	a
IV. May 22	43.5	a	1162	b	2393	a
1996						
I. April 19	13.7	c	549	d	1881	b
II. May 1	16.0	c	744	c	2401	a
III. May 9	24.8	a	1273	a	2195	a
IV. May 23	19.9	b	995	b	1843	b
1997						
I. April 21	29.0	c	1591	a	3085	a
II. May 5	32.8	bc	1654	a	2566	a
III. May 15	36.3	b	1694	a	3071	a
IV. May 28	42.5	a	1103	b	3200	a

[1] Data are the mean value for the untreated check.
[2] Counts of infection centers in the two center rows of each plot.
[3] Yields are based on weight of peanuts with moisture content of 7% (w/w).
Means followed by the same letter(s) within the same year are not significantly different at $P \leq 0.05$ according to the Waller-Duncan *k*-ratio *t* test.

Table 8. Effect of fungicide spray programs on disease incidence at harvest, area under the disease progress curve, and pod yield averaged across planting dates in 1994 and 1995.

Treatment, rate a.i./ha, and spray program[1]	DIH[2] 1994	DIH[2] 1995	AUDPC[3] 1994	AUDPC[3] 1995	Yield (kg/ha)[4] 1994	Yield (kg/ha)[4] 1995
fluazinam 0.58 kg						
Original FDI 32 algorithm	22.0 c	8.9 d	519 c	755 bc	3452 a	4480 a
Demand[5]	37.5 b	11.4 d	1073 b	628 c	2676 b	4754 a
iprodione 1.12 kg/ha						
Original FDI 32 algorithm	40.0 ab	19.3 c	1166 b	806 bc	2279 c	3738 b
Demand[5]	34.4 b	23.1 b	1094 b	883 b	2152 c	3716 b
Untreated check	45.0 a	40.3 a	1602 a	1690 a	1613 c	2267 c

[1] Fungicide programs called for two and three applications in 1994 and 1995, respectively.
[2] Disease incidence at harvest (DIH) are counts of disease foci from the two center rows of each plot.
[3] Area under the disease progress curve (AUDPC).
[4] Yields are based on weight of peanuts with moisture content of 7% (w/w).
[5] Demand treatments utilized 4 wk and 3 wk fungicide protection periods in 1994 and 1995, respectively.
Means followed by the same letter(s) are not significantly different at $P \leq 0.05$ according to the Waller-Duncan *k*-ratio *t* test.

Table 9. Growth stages of peanut in each planting date from 1995 to 1997.

Year and plant date	Growth stage[1]					Disease onset[2]
	VE	R1	R2	R3	R4	
1995						
I. April 20 . . .	8 May (18)[3]	13 Jun (54)	22 Jun (63)	10 Jul (81)	16 Jul (87)	4 Jul (75)
II. May 1	14 May (13)	16 Jun (46)	27 Jun (57)	10 Jul (70)	21 Jul (81)	4 Jul (64)
III. May 9	19 May (10)	16 Jun (38)	30 Jun (52)	10 Jul (62)	21 Jul (73)	4 Jul (56)
IV. May 22	2 Jun(10)	30 Jun (39)	10 Jul (49)	16 Jul (55)	28 Jul (67)	16 Jul (55)
1996						
I. April 19 . . .	7 May (18)	12 Jun (54)	27 Jun (69)	4 Jul (76)	16 Jul (88)	15 Jul (87)
II. May 1	14 May (13)	20 Jun (50)	27 Jun (57)	4 Jul (64)	16 Jul (76)	15 Jul (75)
III. May 9	22 May (13)	20 Jun (42)	27 Jun (49)	16 Jul (68)	22 Jul (74)	15 Jul (67)
IV. May 23	5 Jun (13)	27 Jun (35)	16 Jul (54)	22 Jul (60)	11 Aug (80)	29 Jul (67)
1997						
I. April 21 . . .	7 May (16)	27 Jun (67)	3 Jul (73)	14 Jul (84)	28 Jul (98)	4 Aug (105)
II. May 5	12 May (7)	27 Jun (53)	3 Jul (59)	21 Jul (77)	5 Aug (92)	4 Aug (91)
III. May 15	22 May (7)	3 Jul (49)	14 Jul (60)	28 Jul (74)	5 Aug (82)	4 Aug (81)
IV. May 28 . . .	12 Jun (15)	14 Jul (47)	21 Jul (54)	28 Jul (61)	5 Aug (69)	4 Aug (68)

[1] VE=emergence, R1=flowering, R2=pegging, R3=early pod, R4=full pod as described by Boote (2).

[2] Disease onset was detected by weekly scouting.

[3] Numbers in parentheses indicate days after planting.

nearly achieved row closure in plant date IV. Disease progress did not begin to increase rapidly in plant date IV until mid-September, when the completion of row closure coincided with environmental conditions that were favorable for disease development. The final disease ratings in plant date IV averaged 43.5 in the untreated check, and was higher than those of other plant dates (Table 7).

There was no interaction between fungicide treatment and planting date in 1995. A split-plot analysis indicated that the effect of planting date was significant for AUDPC, while fungicide treatment had a significant effect on DIH, AUDPC and yield (Tables 7 and 8). Plant date I demonstrated a significantly higher AUDPC than plant date IV. All spray programs called for three fungicide sprays in 1995. A significant reduction in DIH was observed when iprodione was applied according to the original FDI 32 algorithm in comparison to the demand program. Overall, both fungicides significantly reduced DIH and AUDPC while significantly improving yield. However, fluazinam did perform significantly better than iprodione according to DIH and significantly increased yield 890 kg/ha over similar iprodione treatments.

1996 Field Tests. The 1996 season was cool and wet with rainfall accumulation 5.8 cm above normal at the test location. Disease first appeared on 15 July in plant dates I, II, and III after heavy precipitation from hurricane Bertha. At this time, vines between adjacent rows were near 6.4, 8.9, and 6.6 cm from touching between rows, respectively (Table 6). Vine growth in plant date IV was significantly less than that of earlier plant dates by 16 July which resulted in disease onset being delayed until 29 July when vines between adjacent rows were near row closure. Disease progress increased rapidly once disease onset occurred in all plant dates, but plant date IV showed a more rapid increase from the time of disease onset until early September (Fig. 5). Disease onset occurred in all plant dates subsequent to pegging (Table 9).

A split-plot analysis indicated no significant treatment by planting date interaction in 1996. However, the effect of planting date and fungicide treatment was significant for DIH, AUDPC, and yield (Tables 7 and 10). Plant dates I and II had a significantly lower DIH and

AUDPC than plant date III. Yield was significantly higher in plant dates II and III. The original FDI 32 and variable threshold algorithms received an average of 2.8 and three sprays, respectively. Demand treatments were omitted from the data analysis due to an error in application. The most significant reductions in both DIH and AUDPC in 1996 were achieved by fluazinam treatments applied according to the original FDI and the mod. vine/air-soil temp. algorithms with DAP-dependent thresholds (Table 10). Iprodione applied according to the FDI 32 and DAP-dependent threshold versions of the original algorithm reduced the AUDPC significantly below the untreated check. All fungicides and spray programs increased yield significantly compared to the untreated check, except iprodione applied according to the original FDI 32 algorithm. Fluazinam applied according to the original FDI 32 and the DAP-dependent threshold version of the original FDI algorithm increased yield 1042 kg/ha over similar treatments of iprodione in 1996.

1997 Field Tests. The 1997 growing season was cool and dry with rainfall accumulation 16 cm below normal. Disease onset occurred on 4 August which was 15 days after 8.1 cm of accumulated rainfall. Disease progressed rapidly until mid-August before becoming static throughout the rest of the season due to rainfall deficits which lasted through September (Fig. 5). Plant date IV exhibited significantly less plant growth than plant dates I, II, and III at the time of disease onset which may explain why disease progress was much slower initially (Table 6). However, disease began to progress rapidly in plant date IV in early to mid-September following row closure and a more favorable environment. Disease onset occurred subsequent to the beginning pod stage in plant dates II through IV and after the full pod stage in plant date I (Table 9).

Interactions between plant date and fungicide treatment were not significant in 1997 according to a split-plot analysis. Significant effects of planting date were detected in DIH and AUDPC while fungicide treatment was significant for DIH, AUDPC, and yield. DIH was significantly lower in plant date I while plant date IV demonstrated a significantly higher DIH when compared to the other plant dates (Table 7). This contrasts with the significantly lower AUDPC observed in plant date IV. Both the demand program and the mod. vine/air-

Table 10. Effect of fungicide spray program on disease incidence at harvest, area under the disease progress curve, and pod yield averaged across planting dates in 1996 and 1997.

Treatment, rate a. i./ha, and spray program[1]	DIH[2]				AUDPC[3]				Yield (kg/ha)[4]			
	1996		1997		1996		1997		1996		1997	
fluazinam 0.58 kg												
Original FDI 32	17.9	b	29.8	b	865	c	1575	a	2275	ab	3143	bc
Original w/DAP-dependent threshold	12.9	c	20.4	c	534	d	1162	b	2499	a	3477	a
Mod. vine/air-soil temp. w/DAP-dependent threshold	12.9	c	18.4	c	546	d	1055	b	2264	ab	3481	a
Demand + 3 wk + 3 wk	-[5]		21.5	c	-		1201	b	-		3292	ab
iprodione 1.12 kg												
Original FDI 32	21.2	ab	28.9	b	1069	b	1435	a	1747	cd	3026	c
Original w/DAP-dependent threshold	24.3	a	29.6	b	1053	b	1587	a	1985	bc	2987	c
Demand + 3 wk + 3 wk	-		26.4	b	-		1433	a	-		3296	ab
Untreated check	24.3	a	34.9	a	1398	a	1565	a	1584	d	2987	c

1 DAP-dependent thresholds were: FDI=16 $\leq$ 90 DAP, FDI=32 $\leq$ 120 DAP, FDI=64>120. Number of fungicide applications averaged across plant dates: original FDI 32 algorithm = 2.8 and 2.0 in 1996 and 1997, respectively; original algorithm w/DAP-dependent variable thresholds = 3 and 2.5 in 1996 and 1997, respectively; mod. vine/air-soil temp. algorithm w/DAP-dependent thresholds = 3 sprays for both 1996 and 1997; demand + 3 wk + 3 wk = 3 sprays for 1997.

2 Disease incidence at harvest (DIH) are counts of disease foci in the two center rows of each plot.

3 Area under the disease progress curve (AUDPC).

4 Yields are based on weight of peanuts with moisture content of 7% (w/w). Means followed by the same letter(s) are not significantly different at $P \leq 0.05$ according to the Waller-Duncan *k*-ratio *t* test.

5 1996 demand treatment data were omitted due to a fungicide application error.

soil temp. algorithms with DAP-dependent FDI thresholds called for three sprays in 1997, while the original FDI 32 and DAP-dependent threshold algorithms triggered two and 2.8 sprays, respectively (Table 10). Fluazinam applied according to the demand program as well as the original FDI algorithm and the mod. vine/air-soil temp. algorithms with DAP-dependent thresholds significantly reduced DIH and AUDPC when compared to the original FDI 32 algorithm. Significant yield improvement was shown when fluazinam was applied according to the original FDI and mod. vine/air-soil temp. algorithms with DAP-dependent thresholds and the demand program. Iprodione improved yield significantly only when applied according to the demand program.

DISCUSSION

Since weather conditions varied greatly from year to year, the effects of vine growth, canopy development and peanut growth stage could be evaluated along with the effect of planting dates. Early planted peanuts reached the full pod stage before the later planted peanuts each year (Table 9). Disease onset did not appear to be related to any particular plant growth stage, except that it always occurred after flowering. Growing conditions in 1994 resulted in all four planting dates having similar vine growth by late July, indicating that disease onset and progress was limited by environmental conditions. Once the environment became favorable for the development of Sclerotinia blight, disease progressed across all plant dates at a similar rate (Fig. 5). In 1995 and 1996, however, vine growth appeared to be the limiting factor for disease development since reduced vine growth in the late planted peanuts delayed disease onset. The vine growth of the host also played a major role in 1997 as disease onset was delayed in plant date IV compared to the earlier planting dates. The slower disease progress in the 1997 plant date IV was similar to that observed in plant date IV of 1995. Another similarity between 1995 and 1997 plant date IV was that disease progressed very rapidly and surpassed disease incidence levels in the earlier planting dates once row closure was achieved. Porter et al. (18) also observed that disease incidence at harvest was higher for later plantings. Host growth characteristics were likely more important determinants of disease development in 1995 and 1997 due to the rainfall deficits encountered during both growing seasons. Rainfall was above average in 1994 and 1996 allowing disease to progress at a similar pace in all plant dates, except for plant date IV in 1996. These observations correspond well with the AUDPC data in that plant date IV demonstrated consistently lower AUDPC values when compared to other plant dates except in 1996. Mozingo et al. (10) reported from one test in 1985 that earlier plantings of peanut were more susceptible to Sclerotinia blight when disease ratings for all planting dates were recorded on 13 September. However, these data conflict with previous work which showed that earlier planting tended to reduce the incidence of Sclerotinia blight in peanuts (11) and alfalfa (25). The basis for reducing disease with earlier planting was derived from research showing that older, more lignified tissue was less susceptible to disease (3, 4, 6). Research conducted in this study demonstrates that Sclerotinia blight development in peanuts is more dependent on the environment and host growth than on the age of host tissue.

Variability in weather patterns across growing seasons and differences in the vine growth and foliar canopy between different planting dates provided a mechanism for testing the utility of weather and host-based algorithms for determining the most effective timing of fungicide sprays. In 1994 and 1995, fluazinam and iprodione applied according to the original FDI 32 algorithm performed as well as or better than demand treatments. In contrast, demand treatments tended to perform better than the original FDI 32 algorithm in 1997. In 1996, the first application of fungicide according to the original FDI 32 algorithm was applied 4 days after demand sprays in plant date I, and 7 days after demand sprays in plant dates II and III. This occurred again in 1997 when the original FDI 32 algorithm was sprayed 21 days behind the demand spray in all plant dates which resulted in only two fungicide applications compared to three sprays for the demand program.

DAP-dependent threshold algorithms consistently performed as well as or better than demand sprays in both 1996 and 1997. The original FDI algorithm and the mod. vine/air-soil temp. algorithms with DAP-dependent thresholds resulted in sprays being applied an average of 4.8 and 9.5 days prior to demand program sprays in 1996, respectively. These algorithms also called for sprays 3 and 5 days prior to demand program applications in 1997, respectively. The lower initial FDI threshold of 16 when peanuts were within 90 DAP results in earlier fungicide applications when vines were still succulent and highly susceptible to disease. New mod. vine/air-soil temp. indices also increased sensitivity of the algorithm to changes in the host and environment. The original FDI 32 algorithm with DAP-dependent thresholds called for only one spray in plant date I of 1997 which was applied 21 days after disease onset (data not shown). This was the result of the higher DAP-dependent thresholds which were operative in plant date I at the time of disease onset. The same algorithm called for fungicide application 18 days after the demand program in plant date IV of 1997 due to low disease risk caused by a lack of vine growth.

Overall, the data indicated that planting date alteration was not a useful disease management tool for control of Sclerotinia blight. This is primarily due to seasonal variability in growing conditions and the over-riding ability for disease to develop rapidly under favorable environmental conditions after the host reaches a certain level of vine growth and canopy development. Although the data indicated that late planting may reduce losses to disease in years with less vine growth and canopy development, significant reductions in disease were only evident in two of the 4 years. This inconsistency devalues the use of either early or late planting as a disease control measure. Another important factor that must be considered is that late planting can increase the risk of frost damage due to delayed maturity. However, Mozingo et al. (9) reported that digging date and cultivar are more important factors affecting yield and grade than planting date in normal years.

The Virginia Sclerotinia blight advisory program provides an early warning system for disease, improves the timing of fungicide sprays, and provides a means to minimize unneeded fungicide applications. This represents a valuable addition to programs that provide prescription strategies for disease management in peanuts (12). The advisory programs being developed use algorithms which represent the first predictive models to incorporate the growth of the host plant as well as environmental factors in determining disease risk for Sclerotinia blight. Results in 1994 and 1995, indicated that the original FDI

32 algorithm can perform as well as the demand program, which has been the standard program for timing fungicide applications for control of Sclerotinia blight in the U. S. The demand program relies on intensive weekly scouting for the detection of the initial onset of disease (15). Once disease is detected, the first fungicide application is recommended and subsequent fungicide sprays are made at 3-4 wk intervals until 10 days prior to harvest. The major difficulty associated with the demand program is that growers often fail to detect disease in the initial stages of development and before severe crop damage has occurred. The disease warnings at or just prior to disease onset can allow growers to time fungicide sprays more efficiently as well as more effectively. Data from 1996 and 1997 tests demonstrate that algorithms using DAP-dependent thresholds along with new parameters for vine growth and air/soil temperature perform better than the original FDI 32 algorithm. These modified versions of the original FDI algorithm show the greatest potential for improving the timing and efficiency of fungicide sprays for control of Sclerotinia blight in Virginia.

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