Integrated Management of Sclerotinia Blight in Peanut: Utilizing Canopy Morphology, Mechanical Pruning, and Fungicide Timing

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ABSTRACT

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Sclerotinia blight of peanut, caused by *Sclerotinia minor,* generally becomes severe only after vines meet in the row middles and a dense canopy develops. Dense foliage appears to support a microclimate conducive to the colonization of peanut limbs by *S. minor*. Removal of excess foliage before and during a Sclerotinia blight epidemic on the susceptible genotype NC 7 has been shown to reduce the rate of disease progress. Field tests in 1993 and 1994 examined control of Sclerotinia blight among four peanut genotypes (NC 7, VA 93B, NC Ac 18016, and Tamspan 90) with diverse canopy morphologies. Each cultivar had foliage pruned with a rotary mower once (1993 and 1994) or twice (1994) during the season. Applications of fluazinam (9.2 kg a.i./ha) were imposed on the genotype × pruning treatments. Soil temperatures under the canopy of each genotype and pruning treatment were measured and compared. Disease data were collected weekly by counting the number of feet of plants exhibiting lesions with visible fungus growth. Tamspan 90, a resistant Spanish peanut, had the least Sclerotinia blight incidence. Pruning measurably affected soil temperature for approximately 2 weeks following pruning. Removal of foliage reduced disease and increased disease control affected by fluazinam in fields with high disease pressure. In some tests, yields were increased by pruning through a reduction in disease pressure. Yields were lower when peanuts were pruned excessively, especially late in the season. Pruning of excessive vine growth can be an alternative, or complement, to fungicide treatments when done in midseason during favorable weather when moderate to high disease pressure occurs.

Sclerotinia blight, caused by the ascomycete *Sclerotinia minor* Jagger, is an increasingly serious disease in peanut (*Arachis hypogaea* L.) production in the United States. Farmers can lose up to 50% of the yield in seriously affected fields (26).

Specific environmental conditions must be met for infection to occur. Germination of *S. minor* sclerotia is affected by both temperature and humidity (13). *S. minor*–induced diseases of peanut (13) and lettuce (*Lactuca sativa*) (20) are most severe at temperatures of 20 to 25°C and 18°C, respectively. Dow et al. (13) found that sclerotia incubated at optimum temperatures needed a minimum of 12 h for germination. No germination occurs below 95% relative humidity.

Dense foliage has been associated with a more conducive microclimate for rapid growth of *S. minor* (7). Rank vegetative growth has been shown to enhance the severity of diseases caused by *S. sclerotiorum* in dry beans (*Phaseolus vulgaris*), cauliflower (*Brassica oleracea*) and soybeans (*Glycine max*) (5,18,21,23,25).

Changes in microclimate due to different plant canopy structures have been correlated with disease severity in dry bean, potato (*Solanum tuberosum*), and peanut (5,9,25). Diseases caused by *S. sclerotiorum* were partially controlled with the use of cultivars that have open canopies and upright growth habits, which apparently create less favorable conditions for disease development. Coffelt and Porter (11), while screening peanuts for resistance to Sclerotinia blight, found that resistant genotypes in their tests had a more open canopy than the susceptible Virginia-type cultivars. While physiological resistance is important in disease management, the resistance Coffelt and Porter described was apparently morphological as well as physiological (10,11). A combination of resistance mechanisms also was mentioned in field resistance to white mold of dry beans (1).

Removing leaves from grape (*Vitis vinifera*) canopies significantly reduced disease incidence of *Botrytis cinerea* due to increased air movement and improved drying conditions (15,16,19). Similarly, foliar clipping of red clover (*Trifolium incarnatum*) during key points in the disease cycle of Sclerotinia crown and stem rot caused by *Sclerotinia trifolium* provided good control (27). Some of the success was attributed to exposure and drying of the soil surface and a reduction in humidity around the leaves. Pruning or removing the top one-third of the peanut plant significantly reduced Sclerotinia blight of peanut when compared to nonpruned plots (7).

Methods to improve fungicide application to potential sites of infection have been investigated. Fungicidal sprays for control of *S. sclerotium* in dry beans was more effective on open rather than closed type canopies (12). Work done by Smith et al. (30) showed that spraying fungicide for control of *Sclerotium rolfsii* at night (when peanut leaves are folded) resulted in 12% less disease and 6% higher yields. Backman et al. (2) achieved the best control of southern stem rot of peanut when benomyl was applied after a rotary mower was utilized to prune peanut vines. Brune and Bailey (7) showed that fungicide control of Sclerotinia blight of peanut was best achieved after pruning. They speculated that this effect was due to a combination of an unfavorable microclimate for the pathogen plus better fungicide penetration.

Current cultural methods and low levels of partial resistance in commercial cultivars do not adequately control Sclerotinia blight of peanut. The only currently registered fungicide, iprodione (Rovral, Rhone Poulenc Ag. Chem. Co., Research Triangle Park, NC), (22) is not very effective. A new fungicide, fluazinam (ISK, Inc., Cincinnati, OH), has shown a high level of activity against *S. minor* in amended agar media and soil plate experiments. Evaluation of fluazinam in field trials has often, but not always, shown excellent results in decreasing disease incidence and increasing peanut yields (31,32).

The purpose of this study was to determine (i) the role of canopy shape on Sclerotinia blight, (ii) the effect of pruning on the peanut canopy microclimate, and (iii) the interaction of fluazinam and canopy shape characteristics on Sclerotinia blight.

MATERIAL AND METHODS

Four peanut genotypes, NC Ac 18016 (a breeding line with a very upright, compact canopy), VA 93B and Tamspan 90 (commercial cultivars with upright growth habit and open canopies), and NC 7 (commercial cultivar with dense growth and closed canopy), were planted 13 May 1993 and 12 May 1994. NC Ac 18016

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(highly resistant), VA 93B (moderately resistant), and NC 7 (highly susceptible) are Virginia-type peanuts; Tamspan 90 (highly resistant) is a Spanish-type peanut. Fields in 1993 were located near Conway (Northampton County) and Gliden (Chowan County), North Carolina; and in 1994, near Reynoldson (Langston field) and Wiggins Crossroads (Umphlett field), North Carolina (both in Gates County) in fields with a history of Sclerotinia blight. Each plot consisted of four rows 15.24 m long and 0.91 m apart. The two center rows of plots were planted with designated genotypes, while the outside rows (border rows) were NC 7.

Standard production practices such as tillage, fertilizer, herbicide, and fungicide (leaf spot) and insecticide applications were carried out by the farmer (3). A 4 × 2 × 2 factorial experiment, four genotypes, two pruning treatments, and two fluazinam treatments, was studied in a completely randomized block design. Two additional treatments were added in 1994: pruning twice with no fluazinam applications and pruning twice with one fluazinam application. This was a 4 × 7 factorial experiment (4 genotypes × 7 treatments) in a completely randomized block.

Initiation of pruning and spray treatments was based on the appearance of Sclerotinia blight, as determined by scouting (4). Presence of disease was confirmed with the appearance of mycelium and/or lesions. Scouting was initiated on 22 July 1993 and 17 July 1994, when foliage in rows was approximately 30.5 cm apart. Treatments consisted of pruning and/or spraying fluazinam on designated plots. Pruning treatments involved removing approximately the top one-third of the plant with a tractor-mounted rotary mower (IM 600, International World Agritech, Bethel, OH) on 16 August 1993 (96 days after planting [DAP]), 8 August 1994 (88 DAP), and 9 September 1994 (120 DAP). In September 1994, only the top few inches of the canopy were pruned to remove regrowth from the previous pruning treatment. The height of the mower was adjusted for each of the different genotypes in an effort to prune the top one-third of the canopy. The pruning debris was left between rows.

On 17 August (97 DAP) and 14 September 1993 (125 DAP), and 10 August (90 DAP) and 9 September 1994 (120 DAP), fluazinam was applied to the two center rows of designated plots with a tractor-mounted sprayer at a rate of 1.12 kg a.i./ha in 57 liters of water at 276 kPa with three hollow-cone (TX 6 TeeJet-Spraying Systems Co., Wheaton, IL) nozzles per row.

Sclerotinia blight incidence was estimated by counting the number of active disease foci in the two center rows of each plot. A disease focus was defined as the presence of damage caused by *S. minor* on stems in each 30.5-cm section of row. If more than one stem in each section showed damage (mycelium, sclerotia, typical lesion), that section was considered to be a single focus. This takes into account fungal spread from one stem to another in the same section. Data collection began on 22 July 1993 and 17 July 1994, and continued weekly until digging. The area under the disease progress curve (AUDPC) was calculated for each treatment to show the cumulative incidence of Sclerotinia blight on peanut tissue (29).

A square root transformation was performed on AUDPC means before analysis. Analysis of variance was performed using PROC GLM of SAS (SAS Institute, Cary, NC) on both yield data and transformed AUDPC means. Treatment means were separated using the Waller-Duncan *k*-ratio *t* test.

Fields in 1993 were dug on 19 and 24 October (Northampton and Chowan, respectively) and harvested on 25 and 29 October (165 and 169 DAP, respectively). Fields in 1994 were dug on 4 and 10 October (Northampton and Chowan, respectively) and harvested on 11 October (151 DAP). Only the two center rows in each plot were harvested.

Determining effect of pruned canopy on environmental parameters. Environmental data were collected throughout both seasons to determine the effect of pruning and various genotypes on the canopy microclimate. Hygrothermographs (Hi-Q Hygrothermograph, Model 5020 Series, Qualimetrics Inc., Sacramento, CA), designed to measure relative humidity, were placed in plots planted to each of the four genotypes, both pruned and nonpruned, on 1 July 1993 (49 DAP) and were removed 6 October 1993 (146 DAP). In 1994, hygrothermographs were placed only in plots of NC 7, both pruned and nonpruned, on 5 July (54 DAP) and were removed on 7 October (148 DAP). Hygrothermographs were housed in white wooden boxes with wire mesh windows on three sides.

Soil temperatures beneath four genotypes (both pruned and nonpruned plots) were monitored with the use of 21X Microloggers (Campbell Scientific Inc., Logan, UT) in 1993. Thermocouples were placed (at a depth of 5.1 cm) within the peanut row between two adjacent plants on 28 July (76 DAP). High and low temperatures were recorded each day until 6 October (146 DAP). In 1994, thermocouples were placed in the soil 5 July (54 DAP) and removed 7 October (148 DAP).

Soil moisture was monitored weekly in 1994. The top 5.1 cm of soil underneath the peanut canopy was extracted with a soil probe. Six core samples were taken from each plot, placed in a bag, and mixed thoroughly. Forty grams of soil (wet weight) was removed from each composite sample, placed in a 50-ml glass beaker, and dried for 36 h at 41.7°C. Beakers were then reweighed, and percent soil moisture was calculated.

RESULTS

1993 Sclerotinia blight field tests. Sclerotinia blight was not a significant factor in peanut production in 1993 because of a drought. Precipitation data from a nearby North Carolina Climate station

Table 1. Comparison of peanut genotype effect on Sclerotinia blight at Chowan and Northampton county field sites (1993) and Langston field (1994)

	AUDPC[x]		
Genotypes	**Chowan[y]**	**Northampton[z]**	**Langston**
NC 7	16.98 a	8.07 a	8.05 a
NC Ac 18016	9.91 b	8.46 a	7.74 a
VA 93B	7.70 c	6.40 b	7.38 a
Tamspan 90	6.86 c	6.26 b	6.20 b

[x] Area under the disease progress curve. Data means were transformed by square roots before analysis. Means within a column followed by the same letter are not different ($P = 0.05$) according to the Waller-Duncan *k*-ratio test, with $k = 100$. Disease data per 30.48 m of plot (100 row feet) were collected weekly by counting the number of row feet exhibiting active lesions with visible fungal growth.
[y] Irrigated (3.8 cm of water) during key time in drought on 25 August 1993.
[z] No irrigation.

Table 2. Area under the disease progress curve means for the prune × fluazinam interaction for 1993 trials at Chowan County field site over genotypes NC 7, NC Ac 18016, VA 93B, and Tamspan 90

	AUDPC[y]		
Pruning conditions	**Fluazinam-sprayed plots**	**Nonsprayed plots**	**Pruning[z] means**
Pruned	8.62 ns	9.65 a	9.13
Nonpruned	9.50 ns	13.65 b	11.64
Spraying means	9.40	11.65	

[y] Data means were transformed by square roots before analysis for incidence of Sclerotinia blight with prune × spray interaction at $P = 0.05$. Disease data per 30.48 m (100 row feet) were collected weekly by counting the number of row feet exhibiting active lesions with visible fungal growth.
[z] Plots were pruned 96 days after planting (DAP) and sprayed 97 DAP.

showed only 6.22 cm (2.45 in) of rain fell during July and August of 1993 compared with the 40-year average of 21.03 cm (8.28 in) over the same time period (State Climate Office of North Carolina at North Carolina State, Raleigh). The Chowan County farm was irrigated on 25 August 1993 (3.8 cm of water) during a key time of the drought. The Northampton County farm was not irrigated.

In 1993, genotype, pruning, fluazinam treatments, and the pruning × fluazinam interaction had a significant effect on disease in the irrigated Chowan field. Susceptible NC 7 had the highest disease incidence, NC Ac 18016 had moderate, and VA 93B and Tamspan 90 had the lowest disease incidence (Table 1). Pruning the peanut canopy significantly reduced Sclerotinia blight incidence in nonsprayed plots (Table 2). Spraying fluazinam over pruned plots did not enhance disease control when compared with fluazinam applied over nonpruned plots. There was no genotype × pruning or genotype × fluazinam interaction. Yield was affected by genotypes and pruning treatments. Both NC 7 and VA 93B produced significantly higher yields than NC Ac 18016 and Tamspan 90 (Table 3). Pruning significantly reduced yield by an average of 12%.

In the nonirrigated Northampton field, genotype and pruning had a significant effect on disease and yield, and the genotype × pruning interaction also affected yield. Disease, as measured by AUDPC, was greatest on NC 7 and NC Ac 18016 (Table 1). The main effect of pruning also was significant ($P = 0.05$) in the Northampton field. Mean AUDPC value for pruned plots was 6.72, compared with 7.88 for nonpruned plots. There was no main effect of fluazinam, as peanuts sprayed with fluazinam in the Northampton field had similar disease incidence to nonsprayed peanuts.

The genotype × pruning interaction was significant on yield in the Northampton field (Table 4). Pruning reduced yield by 18% on NC 7, 17.4% on VA 93B, and 14.5% on Tamspan 90 compared with nonpruned plots. Although not significant, yield was increased by 12% in pruned NC Ac 18016 plots.

Table 3. Effect of pruning and genotypes on yield for 1993 trials at Chowan County field[y]

Treatment	Yield (kg/ha)
Genotype	
NC 7	5,538 a
VA 93B	5,382 a
Tamspan 90	4,547 b
NC Ac 18016	4,719 b
Pruning condition	
Pruned[z]	4,728 a
Nonpruned	5,386 b

[y] Means followed by the same letter are not different ($P = 0.05$) according to a Waller-Duncan *k*-ratio test, $k = 100$.
[z] Plots were pruned 96 days after planting.

1994 Sclerotinia blight field tests. Both genotype and treatment (fungicide and pruning) affected disease in both field sites. Averaged over all treatments in the Langston field, NC 7, NC Ac 18016, and VA 93B behaved similarly, with significantly higher disease incidence than Tamspan 90 (Table 1). All treatments in Langston field were effective in reducing disease when compared with the control: nonpruned and nonsprayed plots (AUDPC mean 8.91). Pruning plots once or twice without fluazinam applications (AUDPC means 6.90 and 6.93, respectively) was just as effective as using fluazinam alone, fluazinam (one application) plus two pruning events, and fluazinam (two applications) plus one pruning event (AUDPC means 7.44, 6.15, and 7.69, respectively). One pruning event with two fluazinam applications (AUDPC mean 6.15) gave better disease control than no pruning with fluazinam applications (AUDPC mean 7.44) or two pruning events and one fluazinam application (AUDPC mean 7.69).

F values for the Umphlett field data were highly significant for genotype, treatment, and the genotype × treatment (fungicide and pruning) effects. In plots of

Table 4. Effect of pruning × genotypes interaction on yield for 1993 trials at Northampton County field site[y]

	Yield (kg/ha)		
Genotype	Prune[z]	Nonpruned	Genotype means
NC 7	3,936	4,852 *	4,394
VA 93B	4,089	4,954 *	4,521
Tamspan 90	4,170	4,877 *	4,524
NC Ac 18016	3,997	3,509	3,753
Pruning means	4,048	4,548	

[y] Significant differences ($P < 0.05$) between pruned and nonpruned means for a genotype are indicated with an asterisk.
[z] Plots were pruned at 96 days after planting.

Table 5. Area under the disease progress curve (AUDPC) means for effect of genotype × treatment interaction on Sclerotinia blight incidence for 1994 trial at Umphlett field site

		AUDPC[v]				
Prune treatments	Spray treatments	NC 7	VA 93B	Tamspan 90	NC Ac 18016	Treatment means
1X[w]	2X[x]	11.49 c	11.99 c	8.20 b	11.94 e	10.90
1X	…	20.83 b	18.26 bc	9.67 ab	27.33 bc	19.02
…	2X	19.06 b	14.47 c	9.18 ab	18.96 de	15.42
2X[y]	…	21.96 b	23.35 ab	11.63 ab	28.39 b	21.33
2X	1X[z]	23.44 ab	15.64 c	10.19 ab	20.25 cd	17.38
…	…	27.58 a	28.31 a	13.37 a	36.32 a	26.40
Genotype	Means	20.73	18.67	10.37	23.86	

[v] Data means were transformed by square roots before analysis. Means within a column followed by the same letter are not different ($P = 0.05$) according to the Waller-Duncan *k*-ratio test, with $k = 100$. Disease data per 30.48 m (100 row feet) were collected weekly by counting the number of row feet exhibiting active lesions with visible fungal growth.
[w] Plots pruned once 88 days after planting (DAP).
[x] Plots sprayed twice, 90 and 120 DAP
[y] Plots pruned twice, 88 and 120 DAP.
[z] Plots sprayed once 120 DAP.

Table 6. Effect of genotype × treatment interaction on yield for 1994 trial at Langston field site[v]

		Yield (kg/ha)				
Prune treatments	Spray treatments	NC 7	NC Ac 18016	VA 93B	Tamspan 90	Treatment means
1X[w]	2X[x]	4,783 bc	4,618 a	4,435 bc	3,986 b	4,455
1X	…	4,618 bc	3,932 b	4,883 b	4,148 b	4,446
…	2X	5,655 a	5,088 a	5,942 a	5,411 a	5,523
2X[y]	…	4,123 c	3,889 b	4,108 c	4,474 b	4,150
2X	1X[z]	5,127 ab	3,986 b	4,169 c	4,291 b	4,421
…	…	5,167 ab	4,883 a	6,002 a	5,897 a	5,528
Genotype	Means	4,946	4,417	4,923	4,727	

[v] Means within a column followed by the same letter are not different ($P = 0.05$) according to a Waller-Duncan *k*-ratio test, $k = 100$.
[w] Plots pruned once 88 days after planting (DAP).
[x] Plots sprayed twice, 90 and 120 DAP.
[y] Plots pruned twice, 88 and 120 DAP.
[z] Plots sprayed once 120 DAP.

NC Ac 18016, disease incidence was greatest in the control plots, and all treatments provided various levels of disease control (Table 5). The combination of pruning once and two fluazinam sprays compared with the control (nonpruned, nonsprayed plots) reduced the AUDPC by 67%. Pruning once or twice (without fluazinam) reduced the AUDPC when compared with the control, but the addition of two fluazinam applications to pruned plants was more effective in reducing disease than pruning alone. In the other three genotypes, similar treatments were not consistently effective in reducing disease incidence when compared with the control. Pruning NC 7 twice, with one application of fluazinam, did not result in decreased Sclerotinia blight when compared with the control. All other treatments on NC 7 suppressed disease. The combination of pruning with two applications of fluazinam was the most effective treatment, reducing disease 58%. Pruning NC 7 once (without fluazinam applications) was just as effective as using fluazinam. With Tamspan 90, the combination of a single pruning and two fluazinam sprays was the only effective treatment when compared with the control. VA 93B pruned twice, without fluazinam sprays, gave little disease control, but all other treatments were effective. A single pruning was just as effective as either fluazinam alone or the combination of pruning and fluazinam applications on VA 93B.

Genotype, treatments, and the genotype × treatment interaction all affected yield in the Langston field. In all four genotypes, plots that had applications of fluazinam and were left unpruned had yields similar to control plots (Table 6). Pruning, regardless of fluazinam applications, significantly suppressed yield in Tamspan 90 and VA 93B. Pruning of NC Ac 18016 also reduced yield except when it was used in conjunction with two fluazinam sprays. With NC 7, pruning reduced yields (compared with the high-yielding fluazinam-sprayed plots) except in plots that were pruned twice and sprayed once. In the Umphlett field, the combination of a single

Table 7. Effect of genotype and treatment on yield for 1994 trial at Umphlett field site[v]

		Yield (kg/ha)				
Prune treatments	**Spray treatments**	**NC 7**	**VA 93B**	**Tamspan 90**	**NC Ac 18016**	**Treatment means**
1X[w]	2X[x]	4,476	4,598	4,272	4,394	4,435 b
1X	…	3,143	3,947	3,926	3,540	3,638 c
…	2X	4,679	4,842	5,186	5,249	4,991 a
2X[y]	…	3,397	3,255	4,150	3,194	3,498 c
2X	1X[z]	3,357	3,235	3,804	3,336	3,434 c
…	…	3,031	3,540	3,804	3,560	3,484 c
Genotype	Means	3,681 b	3,902 ab	4,191 a	3,879 ab	

[v] Means followed by the same letter within treatment or genotype means are not different ($P = 0.05$) according to a Waller-Duncan k-ratio test, $k = 100$.
[w] Plots pruned once 88 days after planting (DAP).
[x] Plots sprayed twice, 90 and 120 DAP.
[y] Plots pruned twice, 88 and 120 DAP.
[z] Plots sprayed once 120 DAP.

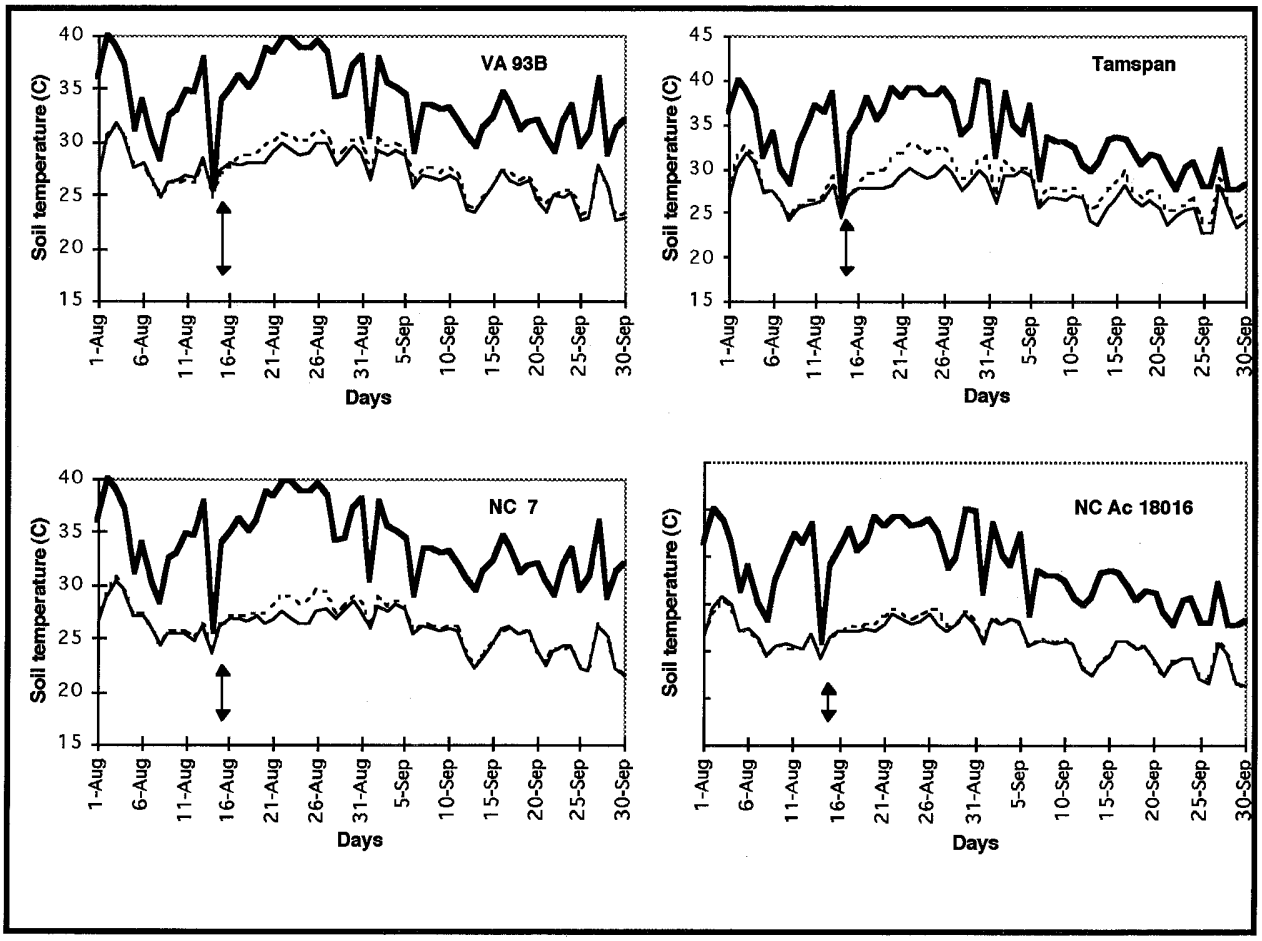

Fig. 1. Soil temperature at 5 cm with bare soil (bold line), below nonpruned canopy (solid line), and below pruned canopy (dashed line) during the 1993 growing season. Time of pruning is represented by vertical line with arrows.

pruning with two fluazinam applications increased yields compared with control plots, but plots that were nonpruned with two fluazinam applications had the highest yields of any treatment (Table 7).

Effect of pruned canopy on environmental parameters. Until plots were pruned on 16 August 1993, differences in soil temperatures between plots to be pruned and nonpruned were minor (Fig. 1). Large temperature differences, as much as 8 to 9°C, were observed throughout the growing season between bare ground (no vegetative cover) and canopy-covered (both pruned and nonpruned) soil. After 16 August, soil temperatures below all four pruned genotypes were consistently warmer when compared with the nonpruned plots. This effect was most pronounced for the 2 weeks immediately following removal of the top one-third of the peanut canopy. Warmer soil temperatures continued for the remainder of the growing season in Tamspan 90 and most of the season for VA 93B. Following the initial 2-week post-pruning period, differences in soil temperatures below pruned and nonpruned plots of NC 7 and NC Ac 18016 were not as striking.

Differences in soil temperature between plots to be pruned and nonpruned also were minor in 1994 (Fig. 2). Bare ground was much warmer at 5-cm depth than canopy-covered soil. After plots were pruned on 8 August, soil temperatures below pruned plants were consistently warmer (about 1°C) throughout most of the growing season. However, soil temperatures below nonpruned canopies exceeded that of bare soil following rain events.

Both pruning and genotype influenced soil moisture underneath canopies in 1994 at the Langston field. Seasonal soil moisture, as measured by area under the moisture progress curve (AUMPC), was greatest under NC 7 (Table 8). NC Ac 18016 had the smallest AUMPC mean, compared with NC 7 and VA 93B. Pruning significantly increased the AUMPC mean by 6%.

Hygrothermograph readings in 1993 and 1994 showed no consistent differences in relative humidity (RH) between pruned and nonpruned genotypes (8).

DISCUSSION

Under conditions of both high (Umphlett in 1994) and low to moderate (Northampton and Chowan in 1993, and Langston in 1994) disease pressure, Tamspan 90 was the most effective genotype in reducing Sclerotinia blight incidence. VA 93B had lower disease incidence during the 1993 growing season, but not in 1994, compared with the more susceptible cultivars. The

Table 8. Area under the moisture progress curve (AUMPC) means for the effect of pruning and genotypes on soil moisture for 1994 trial at Langston field site[z]

	AUMPC		
Genotype	**Pruned**	**Nonpruned**	**Genotype means**
NC 7	50.37	48.23	49.30 a
VA 93B	49.35	47.66	48.50 ab
Tamspan 90	47.92	43.10	45.51 bc
NC Ac 18016	45.80	42.98	44.39 c
Pruning means	48.35 a	45.49 b	

[z] Means followed by the same letter are not different ($P = 0.05$) according to a Waller-Duncan k-ratio test, $k = 100$. Weekly sampling from day after pruning (88 days after planting) until end of season.

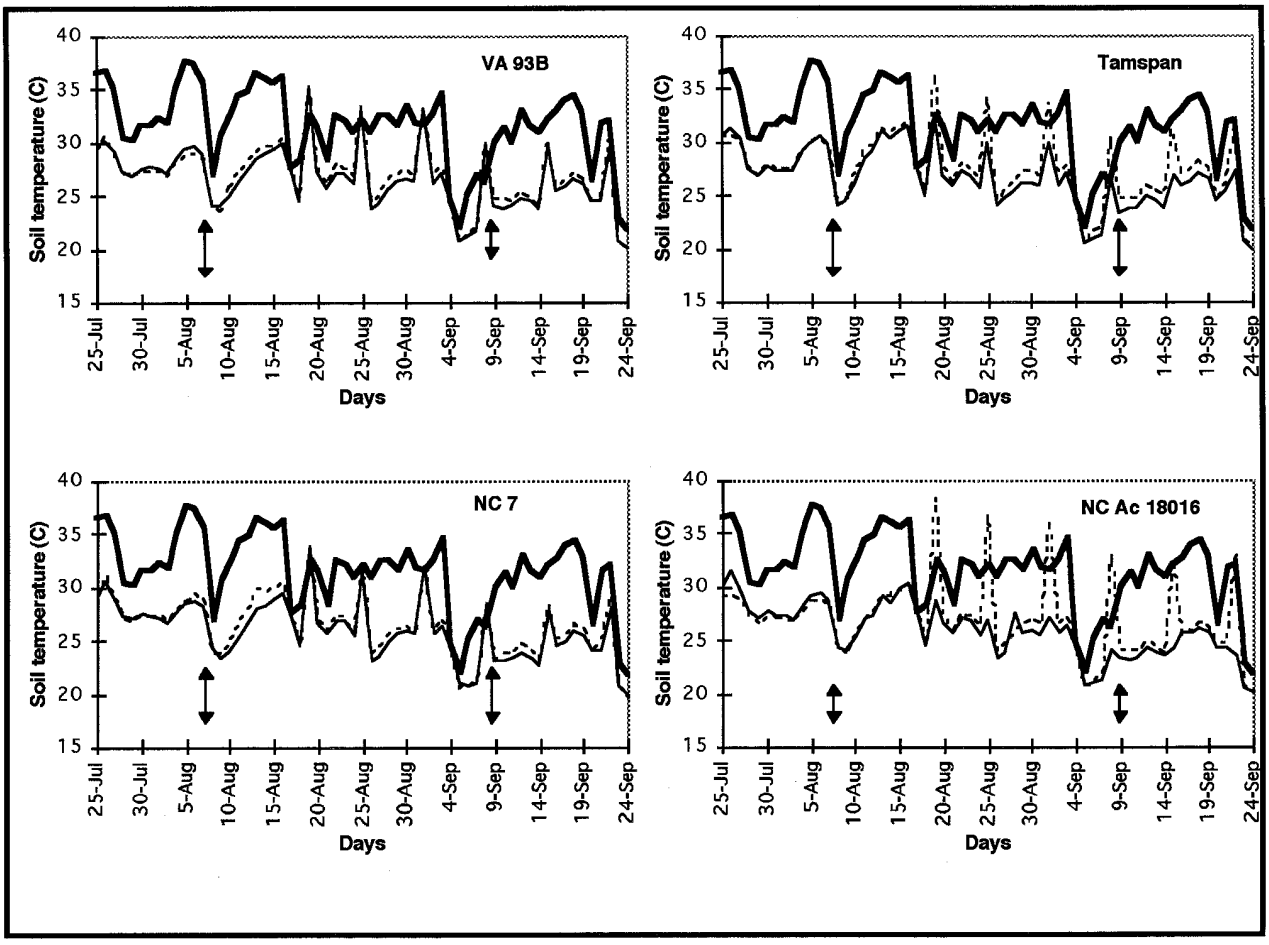

Fig. 2. Soil temperature at 5 cm with bare soil (bold line), below nonpruned canopy (solid line), and below pruned canopy (dashed line) during the 1994 growing season. Time of pruning is represented by vertical line with arrows.

difference in performance of VA 93B between 1993 and 1994 may be related to the amount of rainfall, which influences both the growth of peanut genotypes and conduciveness of environment for infection (13,15) Field resistance with VA 93B and Tamspan 90 has been attributed in part to an upright growth habit and open canopy. Resistance in Tamspan 90 was discovered while screening for early maturation and resistance to pod rot, while VA 93B was specifically bred for resistance to Sclerotinia blight. In both cases, contact of limbs (possible infection sites) with soilborne inoculum is limited. In contrast, limbs of susceptible NC 7 extend across the soil surface. However, upright growth alone does not appear to be sufficient to control Sclerotinia blight. Both fields in 1994 showed that the upright NC Ac 18016 was very susceptible to *S. minor.* An important difference between NC Ac 18016, Tamspan, and VA 93B is that NC Ac 18016 has a dense canopy. Coffelt and Porter (11) showed that canopy structure of resistant genotypes is attributable to disease escape. Research by Schwartz et al. (28) found that it was the combination of growth habit and, more importantly, the distribution of leaf area that influenced the severity of *S. sclerotiorum* on bean cultivars.

Sclerotinia incidence was influenced in these tests by mechanical modification of the peanut canopy. Efficacy of canopy removal for control of Sclerotinia blight, however, depended on the level of disease pressure. In the 1993 growing season (high temperatures and minimal rainfall), very little Sclerotinia blight developed. The 1994 growing season was cooler and wetter. Although both fields in 1994 had a severe history of Sclerotinia blight, only one field (Umphlett) had a damaging level of disease. Disease incidence and severity in Northampton (1993), Langston fields (1994), and the irrigated Chowan field in 1993 were considered to have low-to-moderate disease pressure.

Under both low and moderate disease pressure, pruning resulted in reduced disease; a second pruning did not enhance disease control. In the high disease pressure situation, genotype architecture complemented the pruning treatment to give different levels of control. In the high disease pressure field, pruning had the greatest effect on disease reduction with genotypes having dense canopies, e.g., NC 7 and NC Ac 18016, but also reduced disease incidence in VA 93B with the sparse canopy. Pruning of Tamspan 90 (already possessing a naturally sparse canopy), did not improve disease control.

Several studies have suggested that manipulation (phenotypic or mechanical) of the peanut canopy can be used to manage diseases through microclimate alterations (2,7,13,14). Differences were observed in this study in certain micro-environmental parameters following pruning and between different plant phenotypes. The most noticeable difference was soil temperature. During both growing seasons, soil temperature beneath pruned plots was warmer than that beneath nonpruned plots. Although differences in RH may have existed underneath the canopy, hygrothermographs were unable to detect any differences. These devices were not ideal for this study due to their large size. Sensors that could be placed within the canopy should be used in future pruning experiments so that the canopy structure is not altered, as was the case with the hygrothermograph shelters.

Soil beneath a lush peanut canopy, such as that produced by NC 7, generally had higher soil moisture than soil beneath an open-type canopy peanut like Tamspan 90 and the upright NC Ac 18016. Both sunlight penetration and air movement around Tamspan 90 encouraged moisture loss from the system. However, when comparing moisture underneath pruned and nonpruned canopies, values for the area under the moisture retention curve showed that pruned canopies contained more moisture at a 1- to 5-cm depth than did nonpruned canopies. During the growing season, the main loss of soil moisture is through plant water movement and transpiration (24). Removal of the top one-third of the canopy decreased the amount of leaf area involved with transpiration, which probably resulted in less moisture being extracted from the soil. Although individual environmental parameters did not show great differences between pruned–nonpruned and open–closed-type canopies, the interaction of several microclimate factors was important in disease development.

Recent studies with fluazinam have shown its efficacy on Sclerotinia blight (30,31). Applications of fluazinam in these studies also were effective in reducing disease incidence. The combination of pruning and spraying was not advantageous in 1993 because of low disease pressure, but it did improve control of disease in 1994. In the moderate disease pressure of the Langston field, the combination of pruning and spraying with all genotypes provided much better disease control than the use of fluazinam alone. In the dense, procumbent canopy of NC 7 in the Umphlett field, the most effective control of Sclerotinia was achieved with the combination of pruning and fluazinam. This may be a result of better penetration of fluazinam to infection sites at the soil surface. Although applications of fluazinam can be effective at increasing yields in high disease pressure situations, it offered no increase in yield under low disease pressure.

When disease pressure with Sclerotinia blight was low or moderate (such as Chowan and Northampton 1993, and Langston 1994), pruning was detrimental to yield. Part of this reduction in yield may be attributed to the loss of the most photosynthetically active leaves (6). Yield of sorghum was reduced if the more photosynthetically efficient upper leaves were removed instead of lower leaves (33). Boote et al. (6) were able to show that by removing 25% of the total leaf area (upper canopy), CO_2 uptake was reduced by 30%. Reduced yield has also been attributed to suppressed stem growth. Enyi (17) showed that an increase in stem growth leads to increased yield, while reduction in stem growth due to defoliation led to reduced pod yield.

Management of Sclerotinia blight can be partly achieved through use of fungicides. Although fluazinam has shown great promise in controlling *S. minor*, it is still unregistered in the United States. Sclerotinia blight control can also be achieved by using genotypes that possess an open-type canopy, such as Tamspan 90. However, Spanish-type peanuts are not recommended for the Virginia–North Carolina growing region (34). Of the four genotypes tested, NC 7 is the most popular cultivar in North Carolina and very susceptible to *S. minor*. The combination of pruning once and application of fluazinam in 1994 (heavy disease pressure) was the most effective strategy for NC 7 when compared with other control measures. Only one rate of fluazinam was used in this test; however, reduced fungicide rates in combination with pruning may be just as effective. Although yield was reduced by pruning, the combination of lower fungicide rates (i.e., lower costs) with pruning may compensate for minor yield loss.

Brune and Bailey (7) showed that pruning may have potential as a disease management tactic that can help to eliminate or minimize the need for fungicidal sprays. Economical control of Sclerotinia requires that crop managers understand their disease loss potential and the costs and benefits associated with each disease management tactic. This work supports previous reports that pruning reduces disease incidence; however, yields were often lower than in nonpruned plots. Pruning may be useful when fungicides are not an option or under heavy disease pressure when excessive vine growth exists in wet years.

Plant debris has often been cited as a "food bridge" that exacerbates *S. rolfsii*–induced diseases. Separate field trials were conducted in fields with a history of southern stem rot (*S. rolfsii*) during 1993 and 1994 to determine whether plant debris would influence the incidence of severity of southern stem rot in the field. Canopy debris left behind after pruning in these studies, however, did not enhance southern stem rot (8).

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