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Effects of Modification of the Plant Canopy Environment on Sclerotinia Blight of Peanut

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ABSTRACT

The development of Sclerotinia blight, caused by *Sclerotinia minor* Jagger under various environmental conditions, was studied in field plots of peanuts (*Arachis hypogaea* L.). The peanut plant canopy was modified to produce desired environmental parameters. The modifications included the thinning of canopy foliage to allow air circulation that would decrease canopy humidity and the addition of water-filled troughs under an unthinned canopy that would increase humidity. Canopy relative humidity and soil moisture under the canopy was decreased by canopy thinning. Following infection by *S. minor*, the number of infection foci and disease development was reduced in the thinned canopy; however, thinning also reduced pod yield. Disease development was not increased, nor was yield affected by the addition of the water-filled troughs which increased humidity levels in the canopy. Soil moisture and canopy light interception were important variables in multiple linear regression models for the disease severity index and longest lesion length in the thinned and unthinned-trough plots.

Key Words: *Arachis hypogaea* L., *Sclerotinia minor*, relative humidity, soil moisture, light interception, epidemiology.

Macroclimate conditions can be different from those of the plant microclimate. Because of this, diseases incited by *Sclerotinia* spp. may occur when macro conditions are unfavorable for disease development. For example, white mold of dry beans occurs in the Northern High Plains region of the United States when the macroclimate is hot and dry (11). The microclimate within the canopy is conducive to white mold development due to the influence of the canopy and irrigation (2,10).

Many authors have associated diseases caused by *Sclerotinia* spp. with canopy density (2,6,8). Plant growth habits, that determine canopy density, also have been cited as playing a major role in Sclerotinia disease development (1,5,9).

Plant canopies affect soil temperature, soil moisture, amount and duration of leaf wetness, canopy relative humidity, and canopy temperature (7). The distribution of leaf area near the soil surface, the plant canopy structure, and the plant canopy density associated with the growth habit of the peanut plant are considered factors in determining microclimate effects on Sclerotinia blight development (1). Conditions which are optimum for the development of Sclerotinia blight on inoculated peanut plants in the growth chamber are 20-25 C and nearly saturated humidities (95-100% RH) (3). However, such conditions are uncommon in the macroclimate in the Virginia peanut growing region during most of the growing season (3). Under a dense plant canopy such as that characterized by the growth habit of the peanut plant, conditions are often favorable and conducive to the proliferation of fungi such as *S. minor* Jagger. Canopy modifications were studied because of the apparent importance of the plant canopy in modifying the microclimate conditions near the soil surface. Mycelia from germinating sclerotia near or on the soil surface and near peanut plant tissues (branches, pegs, leaves, etc.) are primarily responsible for initiating infection. Therefore, only conditions affecting soilborne inoculum near plant tissues located near the soil surface need to be considered.

The objectives of this study were: 1) to determine the effect of canopy modification on the development of Sclerotinia blight of peanut; 2) to monitor the effect of these modifications on canopy light interception, soil moisture, canopy relative humidity, and canopy temperature; and 3) relate these changes to Sclerotinia blight development. A preliminary report on this research has been published (4).

Materials and Methods

This study was conducted at the Tidewater Agricultural Experiment Station, Suffolk, VA. Field plots were established in a field planted with cv. Florigiant at the normal seeding rate of 112 kg/ha. Most standard agronomic practices were used in plot management. However, Sclerotinia blight control strategies were omitted. Fungicides used for Cerospora leafspot control were applied with a carbon dioxide pressured-backpack sprayer instead of tractor-mounted spray equipment.

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To manipulate the microclimate below the plant canopy, a test was conducted involving thinning, nonthinning and the use of water-filled troughs. Thinning was used to decrease canopy humidity, and water-filled troughs under the unthinned canopy were used to increase the humidity. A randomized block design with four replications was used. Each block contained three plots with four, 9.1 m rows, 0.91 m apart. Plot treatments were unthinned rows (U), thinned rows (T), or unthinned rows with water-containing troughs (UT). Unthinned rows had an average plant spacing of 10 cm, while thinned rows contained plants seeded no closer than 20 cm. Thinning was done after blossom initiation to prevent growth compensation by the fewer plants in the rows.

Troughs were made from 10 cm diameter corrugated, flexible, polyethylene drainage tubing which was split in half and cut into 90 cm lengths. Drainage tubing end-caps were also split in half and glued with fiberglass resin to make the ends of the troughs. Troughs were located under the canopy approximately 5 cm from the base of the peanut plants. Troughs were placed 60 cm apart, beginning 30 cm from the end of the row. Each row of the trough plots contained six, 90 cm trough sections. Troughs were kept filled with water throughout the season.

Canopy height and width measurements were made during seven weeks of the growing period from August 5th to October 6th. Canopy height was measured from the soil to the tip of the upper leaves of the main stem when the leaves were held fully vertically extended. Plant width and plant height were determined from single plants at 1/4, 1/2, and 3/4 of the way down each of the plot's outer rows. The average measurement for the plot was determined from the six readings.

Weekly soil moisture measurements were made on soil taken from under the plant canopy using a 2.54 cm diameter soil sampling tube. Moisture was determined at the surface to 5 cm and 5 to 10 cm depths. Soil samples, taken 1/4 and 3/4 of the way down each of the two outer rows, were bulked. Only the outer rows of the plots were used for moisture determinations and height and width measurements, thus preventing plant injury and disturbance of the inoculum in the plots center rows where disease development and pod yield were measured.

Temperature and relative humidity (RH) were measured under the canopy of the center rows of each plot in order to relate directly to the disease development measured in these rows. RH was calculated by either a Psychron psychrometer (Bendix Corp., Baltimore, MD) or a digital psychrometer (Atkins Technical Inc., Gainesville, FL). RH was determined by placing the psychrometer under the plant canopy or pointing the digital psychrometer directly into the canopy. Measurements were made between 9:00 and 10:00 a.m., chosen because it was a transition time due to the sun increasing the canopy temperature and affecting the RH of the canopy atmosphere. Two RH readings were made in each of the plot's two center rows. Only two or three plots were read each morning, depending on how rapidly the ambient air temperature changed. Plot section for one day readings was based on a randomized numbers table.

Canopy light interception was measured using a radiometer developed by Wolf *et al.* (12). A reading was made 5 cm above the canopy and another within the canopy along the main stem, 10 cm above the soil surface. The difference between the two readings was divided by the above canopy reading to normalize the data for comparison between different days. Readings were made when the sun was unobstructed by clouds.

To insure that the inoculum would be generally uniform in the plots, *S. minor* was grown at 20-25 C for two weeks on soil-cornmeal (5% w/w) in 30 cm by 46 cm, foil covered dissecting trays. Sclerotia were scraped from the media surface, washed under high pressure tap water for 10 minutes and dried under the transfer hood with constant filtered air flow for 24 h. Each row of the plots was inoculated August 14 with 4 g of dry sclerotia which were sprinkled under the canopy and lightly raked into the top 1 cm of soil. An inoculum density of 0.04 sclerotia/g soil was established in a 30.5 cm wide swath, 1 cm deep, under the canopy of each row.

The two center rows of each plot were observed weekly for development of Sclerotinia blight symptoms. A T-shaped implement with a 61 cm ruled cross piece on one end was used to push back the foliage to allow observation of the base of the plants and the plant tissue lying on the soil surface. A disease severity index (DSI) reading of 0-10 was made weekly for each 61 cm row section based on the observed amount of symptomatic tissue in each section, 0 represented no Sclerotinia blight, 5 represented half of the peanut tissue killed and ten represented all killed by *S. minor*. A longest lesion length (LLL) measurement was also recorded for all of the 61 cm row sections. Fifteen DSI readings and 15 LLL measurements were made for each 9.1 m center row. Thus from every plot, 30 DSI and 30 LLL values were obtained, giving 120 DSI and 120 LLL for each treatment. DSI and LLL measurements were made for 13 weeks beginning mid July and ending at harvest.

Yield was obtained from the two center rows of each plot following mechanical harvesting in October. Quality factors were determined using governmental standards.

Data were analyzed using analysis of variance with Duncan's multiple range test and multiple linear regression techniques. Unless otherwise indicated, a significance level of $P = 0.05$ was used to determine significant differences between treatments. A paired-T test was used for comparing the relative humidities of two treatments read on the same days. This test was used because all plots of all treatments were not read on each day that readings were made.

Results

Sclerotinia blight symptoms were first observed July 21 during the second week of the experiment (Fig. 1). The number of infection foci was far greater in the U and UT plots than in the T plots. On the last day of the season there was an average of 10, 8, and 4 foci per row for the U, UT, and T plots, respectively. Thinning reduced initial infection as evidenced by the reduced number of infection foci. Thinning reduced tissue colonization which was demonstrated by reduced lesion development. Also thinning reduced secondary infections. This was shown by lower disease severity which reflects the branch to branch disease increase from an infection focus as well as the number of foci.

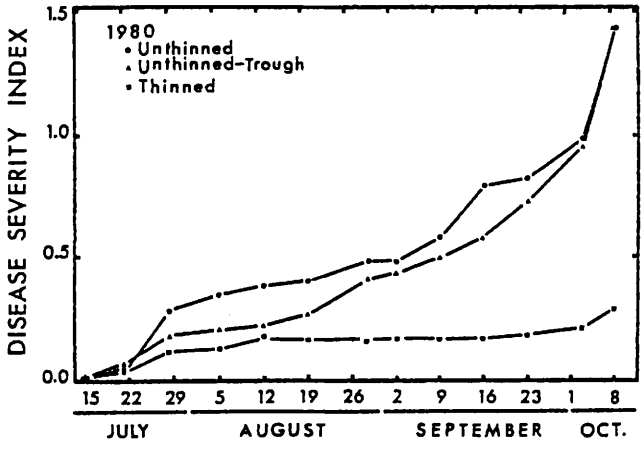

Fig. 1. Sclerotinia blight of peanut disease progress based on the disease severity index (DSI) (120 observations per treatment per date) in unthinned, unthinned-trough, and thinned peanut plots during the 1980 season. DSI was based on a 0-10 scale with 0 = no disease and 10 = complete death of plants in a 61 cm row section.

Figure 1 illustrates the disease progress curves for the U, UT, and T treatments for the growing period based on the DSI. For the first two weeks there were no significant differences in the DSI value for the three treatments. By the tenth week after inoculation the DSI values of all three treatments were significantly different. For nine of the 13 weeks there were no significant differences between the DSI values of the U and UT plots, but these values were significantly higher than the DSI values of T plots. The reduction in DSI was not

simply a linear factor of fewer plants, since the number of plants in the T plots was 60% less than in the U plots yet the DSI was 80% less. A disease progress curve similar to that obtained based on DSI was obtained when the LLL was used (Fig. 2).

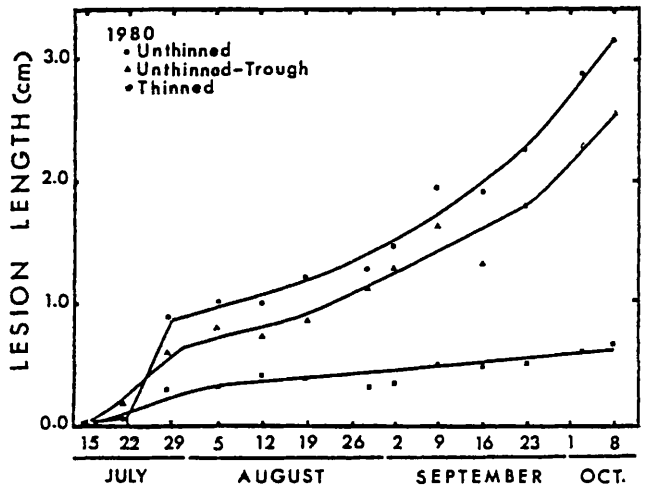

Fig. 2. Sclerotinia blight of peanut disease progress based on longest lesion length (120 observations per treatment per date) in unthinned, unthinned-trough, and thinned peanut plots during the 1980 season.

One day prior to the peanut harvest (October 7), the mean DSI per 61 cm row section was 1.4, 1.4, and 0.3 for the U, UT, and T plots, respectively (Table 1). The mean LLL was 4.6 cm, 4.1 cm, and 2.8 cm for the U, UT, and T plots. At harvest the T plots due to thinning contained significantly fewer plants in the two center rows than the U and UT plots (9.3, 7.8, 3.7, respectively).

Table 1. Comparison of Sclerotinia blight disease severity index (DSI), longest lesion length (LLL) and plant number in unthinned, unthinned-trough, and thinned Florigiant peanut plots one day prior to harvest.

Treatment[v]	DSI[w]	LLL(cm)[xz]	No. Plants[yz]
Unthinned	1.4	4.6 a	9.3 a
Unthinned-trough	1.4	4.1 a	7.8 a
Thinned	0.3	2.8 b	3.7 b

v Unthinned rows had a plant spacing of approximately 10 cm while thinned rows contained plant mainstems no closer than 20 cm. Troughs (90 cm long) filled with water, were placed 60 cm apart and 5 cm from the base of the plants in the unthinned-trough rows.

w Mean of all 61 cm row sections.

x Mean of only diseased 61 cm row sections.

y Mean of all 61 cm row sections.

z Means in columns followed by the same letter are not significantly different (P = 0.05) according to Duncan's multiple range test.

Thinning reduced initial infection as evidenced by the reduced number of infection foci. Thinning reduced tissue colonization which was demonstrated by reduced lesion development. Also, thinning reduced secondary infections. This was shown by the lower disease severity which reflects the branch to branch disease increase from an infection focus as well as the number of foci. The reduction in DSI was not simply a linear factor of fewer plants, since the number of plants in the T plots was 60% less than in the U plots, yet the DSI was 80% less.

Canopy measurements during a seven week period are given in Fig. 3. After August 12, there was no significant difference in within week measurements of width of the plants of the U and UT treatments or in the UT and T treatments. Analysis of all weeks', width measurements of each treatment showed the plants in U rows were wider than those in the UT rows and plants in UT rows were wider than those in the T rows.

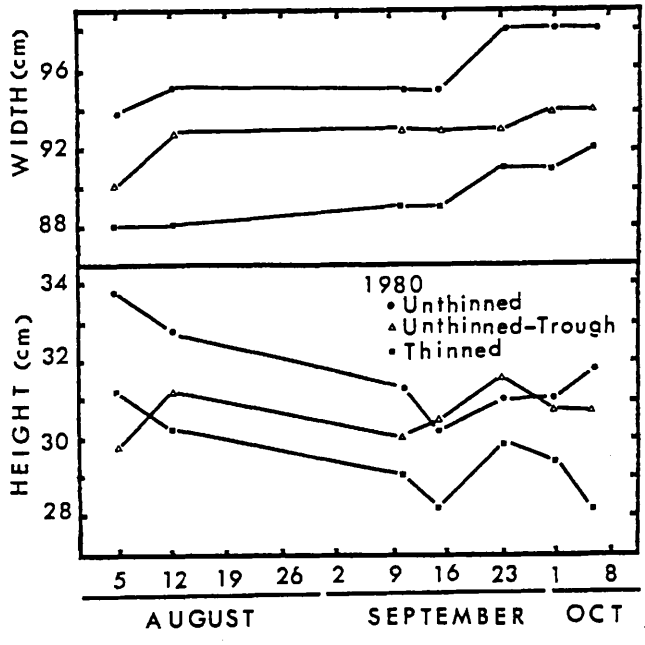

Fig. 3. Canopy development (height and width) in unthinned, unthinned-trough, and thinned 'Florigiant' peanut plots during the 1980 season.

Plant height for the three treatments during seven weeks is illustrated in Fig. 3. For five of the seven weekly readings, there were no significant differences in height between the two unthinned treatments. Results of analyses of all weeks' height data showed plants in the U treatment were taller than the UT plants which were taller than the T treatment plants.

Thinning, as expected, decreased canopy density (Fig. 4). The light interception of the two unthinned treatments (U, UT) was similar in three out of five weeks. In two of the five weeks, canopy light interception in the U plots was greatest. When all weeks of the season were considered, the plant canopy of the U plots was densest and that of the T plots, least dense.

Canopy RH of the U plots was greater than that in the T plots (Fig. 4) but was significantly greater only at P =

0.15. Troughs did not significantly increase RH in the canopy over that of the unthinned rows without troughs, but canopy RH in the UT plots was greater than that in the T plots at P = 0.08.

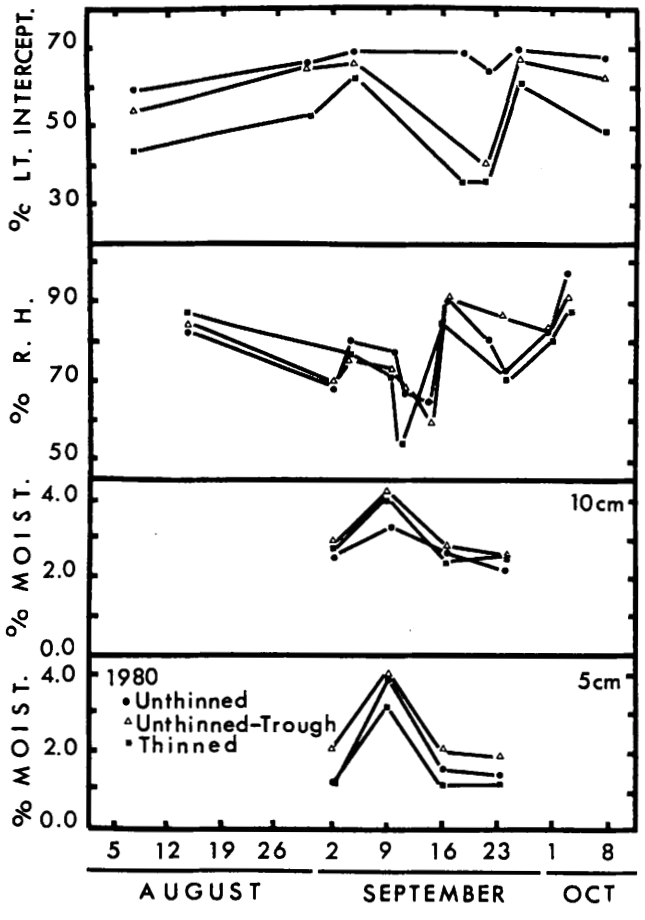

Fig. 4. Percent soil moisture, percent canopy light interception, and within canopy percent relative humidity for the unthinned, unthinned-trough and thinned plots in 1980.

Each week, soil moisture (dry weight basis) under the canopy at the surface to 5 cm depth in the UT plots was greater than in T plots; but there was no significant difference in treatments at the 5 to 10 cm depth (Fig. 4). When all weeks' data were analyzed together, similar results were found for the surface to 5 cm depth. Analysis of all weeks' data at 5 to 10 cm depth indicated soil moisture in UT plots was greater than soil moisture in U plots but soil moisture in T plots was similar to UT and U plots.

Yield was greater in the U and UT than in the T plots with 3280, 2940, and 2270 kg/hectare, respectively. Yield of T plots was 23 and 31% less, respectively, than U and UT plots. The number of plants in T plots was 60 and 53% fewer, respectively, than in U and UT plots.

Stepwise regression of height and width for the season on DSI for the U plots showed that they were significant to the model at P = 0.05 and 0.07, respectively, but the model with only these two factors explained little of the variation in DSI. Similarly, height was significant in a regression on DSI for the T plots. The reverse was the case for the UT plots.

Stepwise regression using light interception and soil moisture for the U plots regressed on the DSI for the same weeks showed light interception to be a significant variable (P = 0.01). This single variable explained 48% of the variation in the DSI. When LLL was analyzed instead of DSI, the soil moisture at the 5 to 10 cm depth was significant (P = 0.03) and explained 38% of the variation in LLL with this single variable model. The slope was positive, indicating that as soil moisture increased, LLL also increased.

Stepwise regression of DSI for the T plots against light interception and soil moisture at the two depths provided a model with soil moisture at the 0 to 5 and 5 to 10 cm depths (significant at P = 0.01), explaining 58% of the variation in DSI.

Stepwise regression of DSI for UT plots with light interception and soil moisture gave a single variable model using light interception (significant at P = 0.001), explaining 71% of the variation. When LLL was used, 90% of the variation was similarly explained.

Discussion

The weather during the 1980 summer was warmer and drier than normal. RH in the canopy was consistently lower than found in the 1978 or 1979 season (R. L. Dow, unpub. data). Typically, drought is the cause of reduced transpiration. With less transpiration, there was less moisture in the canopy atmosphere; therefore, evaporation from the troughs was high. Also, the drought-stressed plants created an open canopy which allowed increased moisture movement out of the canopy. During the 1980 season, for example, troughs did not likely increase the canopy humidity.

Thinning decreased canopy light interception. However, it did not significantly alter the soil moisture, despite the fact that the mean percent moisture for each week was slightly higher in both of the unthinned plots. The small number of samples may not have detected differences between samples. Thus, it cannot be assumed that the increased incidence of disease in the unthinned plots was due to higher soil moisture.

Although the RH differences were not significant at the 95% level, perhaps the results were biologically significant. The numerical difference in RH in the canopies of the U and UT plots as compared with the T plot suggests that RH, combined with the unmeasured duration of high RH periods, may have been important for increased disease development in unthinned plots.

Regression DSI or LLL on percent soil moisture and light interception gave variable results. The UT plot models had 70-90% of the variation in LLL or DSI, explained by the single factor, light interception. The U plots DSI stepwise model was weaker, explaining only 48% of the variation. The model for LLL in the U plots and the model for DSI in the T plots used only soil moisture in a stepwise model.

Consideration of the effects of plant growth on the canopy microclimate of peanuts may be especially important in areas where peanuts are irrigated. The macroclimate temperatures of the southwestern U.S. peanut growing region are not considered conducive to Sclerotinia blight. However, this disease is often found

in moist low lying areas and in areas where irrigation is used. Under these conditions, agronomic practices might be used to modify the canopy microclimate and could, therefore, reduce disease incidence. Some of these practices could include decreased seeding rates, wider row spacing, planting of rows parallel with the prevailing wind direction, use of growth regulators, and use of cultivars with thin canopy structures.

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