Management Tactics that Complement Host Resistance for Control of Cylindrocladium Black Rot of Peanuts[1,2]

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ABSTRACT

Peanut (*Arachis hypogaea* L.) genotypes were evaluated in field microplots infested with *Cylindrocladium crotalariae* (Loose) Bell and Sobers. In experiment I there were three genotypes, two inoculum densities, and two levels (0, 100 kg/ha) of nitrogen (N) fertilizer. A non-nodulating peanut genotype was less susceptible to *C. crotalariae* than either of its nodulating parents. Application of N to the nodulating parents decreased disease severity if inoculum density was low. Application of N to the non-nodulating line increased disease severity compared to disease in unfertilized plots of the non-nodulating line. Experiment II evaluated effects of cultivar (susceptible Florigiant, resistant NC 8C), two inoculum densities, N fertilizer [0, 100 kg/ha), and high carbon:nitrogen organic matter amendment (0, 400 kg/ha). Root rot severity was reduced if the cultivar was resistant, if inoculum density was low, and if N was applied. Soil amendment did not affect disease severity. In experiment III, planting date effects on disease severity were evaluated on resistant NC 8C and resistant NC 18016. Planting on May 2, when minimum soil temperature was below 18 C, resulted in more severe disease than planting on May 17, or May 30, 1983 when minimum soil temperature was above 18 C. Benefits of combining management tactics of resistance, preventing high inoculum densities, N management, and proper planting date are discussed.

Key Words: *Arachis hypogaea*, nodulation, non-nodulating, susceptibility, resistance, *Cylindrocladium crotalariae*, nitrogen fertilizer, planting date, disease management.

The quantitative resistance to *Cylindrocladium crotalariae* (Loos) Bell and Sobers available in peanut (*Arachis hypogaea* L.) breeding lines and in agronomically acceptable peanut cultivars is insufficient for complete control of Cylindrocladium black rot (CBR) (1, 4, 16, 19, 20). Moderately resistant NC 8C is recommended for infested fields in North Carolina and Virginia, but yield losses can occur when NC 8C peanuts are planted in fields with high fungal inoculum densities and/or where environmental conditions are favorable for disease development. Soil moisture near field capacity and soil temperature near 25 C are optimal for disease development (15).

Some disease control tactics are recognized that complement the effectiveness of partial host resistance to *C. crotalariae*. Stress resulting from nematode infection of plants should be avoided because enhancement of CBR by *Meloidogyne, Criconemella,* and *Belonalaimus* nematodes has been demonstrated (7, Black and Pataky, *unpublished*). Crop rotations with nonhosts reduce inoculum density and therefore reduce CBR incidence (16). Metam-sodium (sodium methyl dithiocarbamate) reduced CBR on NC 8C when injected in the soil at a rate lower than that necessary for a similar level of control on susceptible Florigiant (1). Certain soil environments can also reduce CBR. Symptoms of CBR following Ransom soybeans (*Glycine max* (L.) Merr.) were severe on Florigiant but minimal on resistant breeding line NC 3033 (5).

Both incidence of CBR shoot symptoms and pod rot severity were reduced with nitrogen (N) fertilizer in field tests (13). A reduction in the size and number of nodules is a possible mechanism by which N reduced NC 8C susceptibility to *C. crotalariae*. Nodules are highly susceptible sites for infection by *C. crotalariae* (10). However, high rates of N (168 to 504 kg N/ha) reduced peanut yields (13) and N fertilizer is not currently recommended for peanuts in North Carolina and Virginia.

Organic matter in soil can be a N source for plants (low carbon:nitrogen [C:N] organic matter) or can immobilize N (high C:N organic matter) (2). Postharvest corn (*Zea mays* L.) and small grain debris has high C:N ratio but debris of legume crops generally has low C:N ratio.

The objective of this study was to evaluate management tactics for potential use in combinations with host resistance for control of CBR and to investigate the role of nodulation in susceptibility of peanuts to *C. crotalariae.*

Materials and Methods

Three experiments were conducted in 1982 and 1983 in field microplots (76 cm diameter) at Central Crops Research Station, Clayton, NC in Norfolk loamy sand. Microplots were infested with *C. crotalariae* in June 1979. Peanuts, soybeans, and corn were planted in rotations from 1979 to 1981 (experiments I, II) or from 1979 to 1982 (experiment III) (4,5). The inoculum density in each microplot was determined in January 1982 for experiments I and II. Twenty-five soil cores (15 x 2 cm) per plot were bulked, mixed, elutriated, and assayed by dilution plating (17).

The top 46 cm of soil in all microplots in experiments I and II was removed with shovels on May 14, 1982. Microplots were refilled with a mixture of soils based on inoculum density determinations in January 1982 to establish two inoculum density treatments. Low and high inoculum density treatments were approximately 1.3 and 3.1 microsclerotia/g soil in experiment I, and 1.3 and 2.0 microsclerotia/g in experiment II, as determined from soil sampling. The design for experiments I and II was randomized complete block with four replications.

Experiment I evaluated all combinations (3x2x2 factorial) of peanut genotype (a non-nodulating line and its nodulating parents, UF487A-4-1-2 and PI262090)(12), N fertilizer (0, 100 kg N/ha), and relative inoculum density of *C. crotalariae* (low, high). Seeds were furnished by D. W. Gorbet, Agricultural Research Center, Marianna, FL 32446.

Experiment II evaluated all combinations (2x2x2 factorial) of peanut cultivar (susceptible Florigiant, moderately resistant NC 8C), relative inoculum density (low, high), N fertilizer (0, 100 kg N/ha), and high

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C:N ratio organic amendment at planting (0, 400 kg/ha oven-dry chopped corn stalks).

A total of 100 kg N/ha was provided by $Ca(NO_3)_2 \cdot nH_2O$ for fertilizer treatments in experiments I and II. Twenty-five kg N/ha were incorporated preplant into the top 10 cm soil, and additional N was added as sidedressings (without cultivation) of 25 kg N/ha on June 15 , July 5and July 25.

In experiment III, the top 46 cm of soil in microplots used was removed on April 27, 1983. Soil within each replication was mixed together to approximately equalize inoculum densities, and microplots were refilled. Resistant NC 8C and resistant NC 18016 were planted on May 2, May 17, and May 30, 1983. The six treatments were arranged in a randomized complete block design with seven replications.

Recommended management practices were followed (18), including fertilizer and lime, alachlor as herbicide, carbofuran as insecticide/nematicide, methomyl and carbaryl as insecticides, and chlorothalonil as leafspot fungicide. Seedlings were thinned to six plants per plot after emergence. Landplaster (1,120 kg $CaSO_4$/ha) was applied to the soil surface July 15 in all experiments.

Plants were dug September 30, 1982 (experiments I, II) and October 28, 1983 (experiment III). Root rot severity was visually estimated on a 0 to 5 scale with 0 for no lesions and 5 for completely rotted roots (15). Pod rot severity was visually estimated as percent total surface with lesions including pods left in soil.

Results

Experiment I

The non-nodulating line was less susceptible to *C. crotalariae* than its parents, UF487A-4-1-2 and PI262090 (Table 1, Fig. 1). Overall, disease was more severe at high than at low inoculum density (Table 1). Overall, N fertilizer did not affect disease severity, but there were interactions between N and inoculum density ($P=.08$) for root rot severity and between N and genotype ($P<.01$) for pod rot (Table 1). Root and pod rot severity on the nodulating parents were reduced by N when applied to plots having low inoculum density,

Table 1. Severity of Cylindrocladium black rot due to main effects of peanut genotype and relative inoculum density of *Cylindrocladium crotalariae;* interaction between nitrogen fertilizer and genotype; and interaction between nitrogen fertilizer and inoculum density (experiment I).

	Mean disease severity[1]		
Genotype	Root rot	Pod rot	
PI262090	4.51	88	
UF487A-4-1-2	4.06	69	
Non-nodulating	0.72	26	
Fisher's $LSD_{.05}$	0.57	11	
Inoculum density	Root rot	Pod rot	
High	3.35	66	
Low	2.84	57	
Fisher's $LSD_{.05}$	0.46	9	
Nitrogen fertilizer	Root rot (at two inoculum densities)		
	High	Low	
0 kg N/ha	3.13	3.01	
100 kg N/ha (P=.08)	3.57	2.65	
Nitrogen fertilizer[2]	Pod rot (on three genotypes)		
	PI262090	UF487A-4-1-2	Non-nodulating
0 kg N/ha	90	74	14
100 kg N/ha	87	64	39
Fisher's $LSD_{.05}$	15		

[1]Roots rated visually on a 0 to 5 scale and pods rated visually as percent total pod surface with lesions. Disease severity was averaged over the main effect(s) not listed.

[2]Nitrogen supplied by a preplant incorporation and three sidedressings, 25 kg N/ha each, of $Ca(NO_3)_2 \cdot nH_2O$.

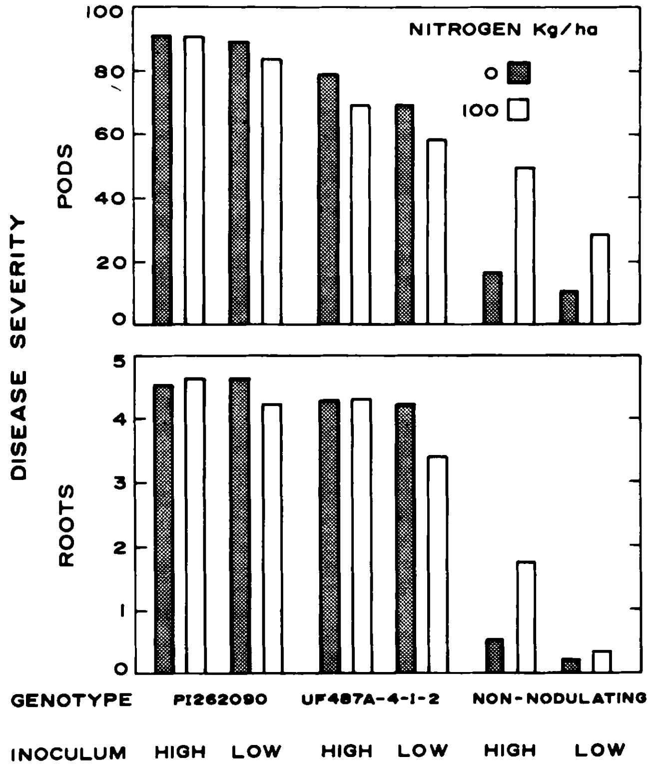

Fig. 1. Severity of Cylindrocladium black rot on pods and roots in response to peanut genotype, relative inoculum density of *Cylindrocladium crotalariae,* and nitrogen fertilizer (experiment I).

but symptoms were increased on the non-nodulating line by N in plots having low inoculum density (Fig. 1).

Nodulating parents had vigorous growth and dark green foliage until individual plants exhibited above-ground CBR symptoms of chlorosis, wilting, and necrosis of shoots. Non-nodulating plants not receiving N fertilizer were stunted and chlorotic throughout the season. Non-nodulating plants that received N were larger and less chlorotic at midseason, but chlorosis was prominent at harvest.

Experiment II

Disease symptoms were more severe ($P<.01$) on susceptible Florigiant than on moderately resistant NC 8C (Table 2, Fig. 2). There was a greater difference in overall pod rot severity between Florigiant and NC 8C than in root rot severity. Overall, root rot severity was less at low than at high inoculum density ($P=.02$), and less if N was applied than if no N was applied (P.01) (Table 2).

Nitrogen applied to Florigiant plants at high inoculum density did not reduce disease severity. However, Florigiant at low inoculum density, and NC 8C at both inoculum densities had less severe CBR if N was applied. Florigiant plants without N had similar disease severity at low and high inoculum density (Fig. 2).

Organic matter amendment did not have a significant effect on CBR severity or nodulation at harvest.

Experiment III

Root rot in experiment III was less severe on NC 18016 than NC 8C but pod rot was more severe on NC 18016 (Table 3). Root rot severity was greater on plants seeded May 2 than on plants seeded May 17, 1983. Pod rot severity was greater for plants seeded May 2 than May 17 or May 30, 1983 (Table 3).

Table 2. Severity of Cylindrocladium black rot due to main effects of peanut cultivar (susceptible Florigiant and moderately resistant NC 8C), relative inoculum density of *Cylindrocladium crotalariae*, and nitrogen fertilizer (experiment II).

	Mean disease severity[1]	
Cultivar	Root rot	Pod rot
Florigiant	4.49	75
NC 8C	2.98	31
Fisher's $LSD_{.05}$	0.55	6
Inoculum density	Root rot	
High	4.09	
Low	3.37	
Fisher's $LSD_{.05}$	0.55	
Nitrogen fertilizer[2]	Root rot	
0 kg N/ha	3.95	
100 kg N/ha	3.52	
Fisher's $LSD_{.05}$	0.17	

[1] Roots rated visually on a 0 to 5 scale and pods rated visually as percent total pod surface with lesions. Disease severity was averaged over the main effects not listed.

[2] Nitrogen supplied by a preplant incorporation and three sidedressings, 25 kg N/ha each, of $Ca(NO_3)_2 \cdot nH_2O$.

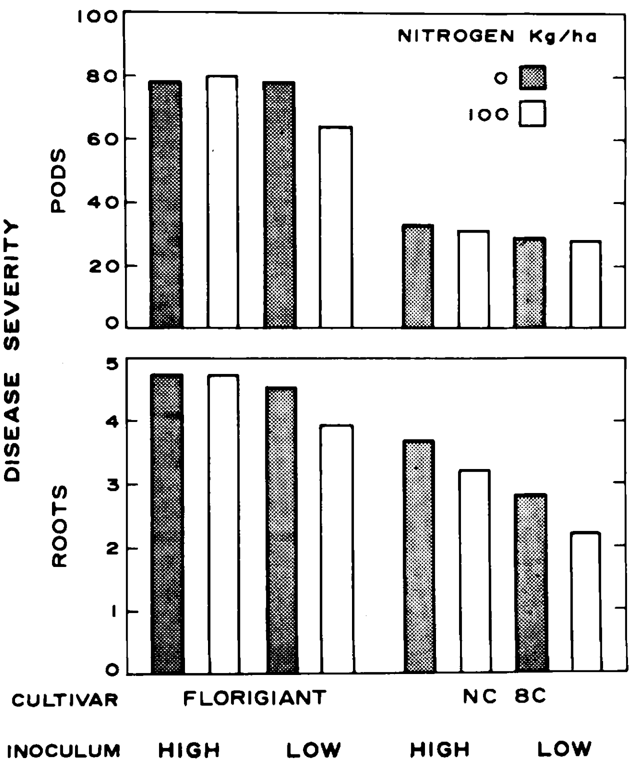

Fig. 2. Severity of Cylindrocladium black rot on pods and roots in response to peanut cultivar (susceptible Florigiant and moderately resistant NC 8C), relative inoculum density of *Cylindrocladium crotalariae*, and nitrogen fertilizer (experiment II).

Discussion

Breeding studies have shown that resistance to *C. crotalariae* is quantitative (9). Therefore, a nodulating progeny of UF487A-4-1-2 and PI262090 should be intermediate to both parents or perhaps similar to one parent in susceptibility. The low severity of CBR symptoms on the progeny of the susceptible parents in experiment I (Table 1, Fig. 1) is apparently related to the progeny's inability to nodulate and consequently the low susceptibility to *C. crotalariae*.

Table 3. Severity of Cylindrocladium black rot due to main effects of peanut genotype (resistant NC 8C and resistant NC 18016) and date of planting (experiment III).

	Mean disease severity[1]	
Genotype	Root rot	Pod rot
NC 8C	2.15	21.7
NC 18016	1.56	29.0
Fisher's $LSD_{.05}$	0.49	7.7
Planting Date	Root rot	Pod rot
2 May 1983	2.29	36.5
17 May 1983	1.54	21.2
30 May 1983	1.73	18.3
Fisher's $LSD_{.05}$	0.60	9.5

[1] Roots rated visually on a 0 to 5 scale and pods rated visually as percent total pod surface with lesions. Disease severity was averaged over the main effect not listed.

Absence of nodules or reduced number of nodules theoretically would lower susceptibility because peanut root nodules are highly susceptible sites for infection by *C. crotalariae* (10). Soybean roots without nodules have also been shown to be less susceptible to a fungus pathogen (*Phytophthora megasperma* f. sp. *glycinea*) than roots with nodules (3). However, the physiology of N stressed non-nodulating peanut plants is unique (12) and the effects of such stress on host suseptibility to *C. crotalariae* are unknown.

Spanish type peanuts nodulate less than virginia types (8), and spanish types are generally more resistant to *C. crotalariae* than virginia types (6,19). Among virginia types, highly resistant NC 3033 nodulates less than moderately resistant NC 8C and susceptible Florigiant (Black, *unpublished*). Selection of competitive rhizobia that induce a low number of small nodules (8) with efficient N fixing capabilities (11) might reduce susceptibility to *C. crotalariae*. Physiological defense mechanisms have been shown to influence relative susceptibility of peanuts (10).

Nitrogen fertilizer as the only management tactic in experiment I was not successful in reducing disease on the nodulating genotypes PI262090 and UF489A-4-1-2 (Fig. 1). However, beneficial effects of N were apparent if inoculum density was low and the slightly less susceptible UF487A-4-1-2 was planted (Fig. 1).

Combinations of resistance, low inoculum density, and/or N were complementary or additive in reducing CBR severity in experiment II (Fig. 2).

More research is needed on the use of N with a resistant cultivar in managing CBR due to the potential for yield depression. It was observed that high N rates at critical times in the season depressed and delayed flowering and reduced yields (13). However, constant N availability or appropriately timed applications may decrease CBR incidence and severity and therefore increase yield. A winter legume incorporated below the fruiting zone may be a practical means to provide peanuts with N at a lower cost than commercial N fertilizer and would also allow for a more constant but decreasing N supply at flower initiation.

Organic amendment of high C:N was included in experiment II to immobilize residual N in soil, and was expected to promote nodulation in the first part of the growing season. However, the amendment did not affect disease symptoms or nodulation as observed at harvest. Organic amendments at high rates usually suppress soil borne pathogens immediately following incorporation (2). Early season enhancement of nodulation and pathogen suppression may have counteracted each other in this experiment.

The interval between planting dates of May 2 and 17 in experiment III resulted in decreased disease severity on two resistant genotypes. Peanut growth occurs if soil temperature is above 18 C with an optimum at 27 C (14). Maximum and minimum soil temperatures at 10 cm (5-day-mean following planting, recorded 900 m from test site) were 25 and 16 C for May 2, 26 and 18 C for May 17, and 28 and 20 C for May 30, 1983 (courtesy of J. H. Young, Biological and Agricultural Engineering, North Carolina State University, Raleigh). Plant growth following the first planting probably stopped at night when the soil temperature dropped below the 18 C threshold for growth. Also, the day temperature was near optimum for disease development but slightly below optimum for plant growth. The mean minimum temperatures following the second and third planting dates did not go below the threshold for growth, and day temperatures were above optimum for disease development and near optimum for plant growth. Low temperature stress sufficient to cease plant growth may impair plant defense mechanisms.

Current recommendations in North Carolina are to plant peanuts when soil temperature 10 cm below the surface at 1300 hr has been 18 C or greater for three consecutive days (14). Soil temperature guidelines for determining planting date for fields infested with *C. crotalariae* may need adjusting upward. Perhaps the mean minimum (rather than the maximum) temperature for 3 consecutive days should be above 18 C. More research is needed to determine the best recommendation for infested fields.

The reversed ranking of the genotypes for root rot and pod rot severity in experiment III was probably related to fruiting habit. NC 8C has a runner growth habit and pod formation is dispersed. NC 18016 has a bunch growth habit and pod formation is densely clustered around the taproot. A high concentration of pods may have allowed pod-to-pod spread of the pathogen on NC 18016. Different genotype rankings for root and pod rot severity have been observed previously (6,19).

These studies demonstrate four factors useful in a management program to minimize losses from CBR. These are: minimizing inoculum density of *C. crotalariae,* managing N, planting a resistant cultivar, and choosing a proper planting date.

A single approach to CBR control cannot prevent disease loss in every situation. However, combinations of several management tactics should result in consistent and high levels of disease control and therefore minimize monetary losses. Tactics not addressed in this study that also should be used for CBR management are control of plant parasitic nematodes that enhance CBR (7) and sanitation of farm implements when leaving infested fields.

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