Occurrence of Pod Rot Pathogens in Peanuts Grown in North Carolina

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ABSTRACT

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Pod rot diseases historically caused significant losses in peanut production in North Carolina. Advances in the understanding of pod rot diseases and changes in cultural practices minimized losses in the years since 1979. By the early 1990s, however, some peanut growers began to observe pod rot that apparently was not associated with infection by common soilborne pathogens. Incidence of pod rot also was high in research plots used to study conservation tillage methods. Selected farms were surveyed in the fall of 1994, 1995, and 1996 to identify the fungi associated with pod rot symptoms in North Carolina. Over the three years of the study, more than 6,000 symptomatic pods from 125 peanut fields were assayed for *Rhizoctonia* spp., *Pythium* spp., *Cylindrocladium parasiticum*, *Sclerotium rolfsii*, and *Sclerotinia minor*. All five pathogens were isolated during the field survey, with *Pythium* spp. and *Rhizoctonia* spp. isolated most frequently. *Rhizoctonia* spp. were the dominant pathogen in the majority of fields in 1994, whereas *Pythium* spp. predominated in 1995 and 1996. Combinations of pathogens were identified from 12 to 15% of pods; *Rhizoctonia* spp. + *Pythium* spp. and *Pythium* spp. + *C. parasiticum* were the most frequent combinations. The mean estimated incidence of pod rot was 6.6% in 1995 and 5.9% in 1996. The effects of cover crops and tillage on pod rot incidence were studied in microplots in 1995 and 1996. In 1995, winter cover crops (wheat, oat, rye, and fallow soil) did not affect pod rot incidence, but incidence was greater in no-till treatments compared to plots with conventional tillage. Pod rot incidence did not differ among infestation treatments and no interactions among pathogen, cover crop, or tillage treatments were significant. In contrast, significant ($P = 0.04$) interactions among winter cover crops and tillage occurred in 1996. Tillage did not affect pod rot incidence following wheat or oats, but incidence following rye was much greater in no-till than in tilled plots.

Additional key words: *Arachis hypogaea*, groundnut

Pod-rotting diseases of peanut (*Arachis hypogaea*) can be caused by an array of soilborne microbes (22). The prevalence of various pod rot pathogens differs among production regions, farms, and even from year to year within a given location. Many different fungi can infect peanut pods sequentially or simultaneously, and the rotting potential of individual pathogens may be enhanced (9) or suppressed (10) by other organisms. Soilborne nematodes, insects, and mites also increase the inci-

dence of peanut pod rot by injuring pods (11,21) or by carrying the pathogens from pod to pod during feeding (23). Widespread use of soil nematicides and insecticides during the past 20 years probably has reduced pod rot losses in southeastern production regions.

Pod rot diseases have caused significant losses in peanut production in North Carolina. Although sporadic in occurrence state-wide, yield losses due to pod rot were greatest during the 1960s and 1970s, when they were estimated to exceed 20% (26,27). Pod rot was most frequently associated with *Pythium* spp., especially *Pythium myriotylum*, and to a lesser extent, with *Rhizoctonia solani* (14). Advances in the understanding of the biology of the pod rot complex, together with changes in cultural practices (4,26), appear to have minimized losses since 1979. During this period, *Sclerotium rolfsii*, *Sclerotinia minor*, and especially *Cylindrocladium parasiticum*, were the most important soilborne pathogens of peanut in the Virginia-Carolina production region. Although these fungi can seriously damage pods, they are primarily stem or root pathogens (22). By the early 1990s, however, some peanut growers began to observe pod rot that ap-

parently was not associated with above-ground symptoms of these diseases. Furthermore, observations in research plots suggested that conservation tillage methods could lead to increased pod rot incidence (L. M. Ferguson and G. C. Naderman, *personal communication*). It is not clear if pod rot is becoming important once again, which fungi might be involved, or what cultural and site factors are associated with pod rot.

The purpose of this research was to evaluate the current status of pod rot on peanut grown in North Carolina. A multi-year survey was conducted to identify some of the fungal species associated with pod rotting in major peanut-growing counties. Controlled experiments in microplots were used to determine whether tillage practices or winter cover crops affect pod rot incidence.

MATERIALS AND METHODS

A total of 15 farms, located in six counties in northeastern North Carolina, were surveyed for pod rot pathogens in October 1994. In 1995 and 1996, 55 farms from 11 peanut-producing counties (five farms/county) were surveyed in each year. These counties accounted for more than 90% of peanut production in North Carolina (19). The surveys were conducted during periods of highest digging activity, and freshly dug fields were selected arbitrarily during each survey trip. Each field was recorded with the farmer's name and county; additional information about agricultural practices was obtained from growers or county agents. The percent incidence of pod rot also was estimated visually for each field. In 1996, soil cores (2.5 by 15 cm) were collected along a zigzag path in each field, and a pooled soil sample from the field was submitted to the North Carolina Department of Agriculture Agronomic Division for fertility analysis.

In all 3 years, at least 200 pods with symptoms of pod rot were collected from arbitrarily selected sites within each field; areas with obvious symptoms of root and stem diseases were avoided. Only partially rotted pods were selected. Highly degraded pods were not included in samples. Pods were placed on ice in plastic bags for transport and were stored in a cold room at 5°C until isolations were made. Of the 200 pods from each site, 50 were assayed for several peanut pathogens: *Cylindrocladium parasiticum* Crous, Wingfield, and Alfenas; *Pythium* spp.; *Rhizoctonia solani*;

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Sclerotium rolfsii; and *Sclerotinia minor*. Isolations for all five pathogens were attempted from each pod. Pods were washed lightly over a 6-mm screen to remove surface debris and air-dried briefly on paper towels, after which an approximately 1-cm² piece was cut through the exocarp of each pod. Pieces usually included a small section of the seed in addition to the exocarp. This piece was cut into three smaller pieces that were placed individually into each of three petri dishes containing media semi-selective for the target pathogens. The medium for *Pythium* spp. was modified from Eckert and Tsao (6) and contained 50 µg/ml penicillin G, 35 µg/ml pimaricin (natamycin), and 50 µg/ml polymyxin B. Difco bacto agar (2%) was used for *R. solani*, and a semi-selective medium developed by Phipps et al. (20) was used for isolations of *C. parasiticum*. Plates were incubated for 2 days for *Py-*

thium spp. and *Rhizoctonia* spp., and 5 days for *C. parasiticum*. The remaining portion of each pod was placed in a plastic incubation chamber (24 by 16 by 4 cm) lined with moistened paper towels. Pods were incubated up to 1 week and observed for growth of mycelia characteristic of *Sclerotinia minor* or *Sclerotium rolfsii*. More than 6,000 pods were assayed over the 3 years of this study. Some isolates of the fungi were subcultured and stored for later use. Selected *Pythium* isolates from 1994 and 1996 were subcultured on V-8 agar and grown on boiled grass leaves for identification to species (17,25).

The mean percentage of pods yielding the fungi assayed was calculated for each sample. Means from fields having different histories (rotation and pesticide usage) were compared with *t* tests. Product-moment correlations were calculated among pathogen, disease, and soil variable means

from 1996 samples. Principal components analysis was conducted with the number of factors retained in the final analysis determined according to the MINEIGEN criteria of SAS procedures (SAS Institute Inc., Cary, NC).

Four soil treatments were established in field microplots located at the Central Crops Research Station in Clayton, North Carolina that previously were treated with 63 g m⁻² sodium methyl dithiocarbamate. Plots were approximately 80 cm in diameter and consisted of a 60-cm-wide sheet of fiberglass installed 50 cm deep in soil (1). Soil was infested with isolates of *Rhizoctonia solani*, *Pythium* spp., both pathogens, or no pathogens added to soil. A composite of five isolates of each fungus originally obtained from the 1994 survey was used to infest the microplots. *Pythium* isolates were cultured on corn meal-sand medium (17) and *Rhizoctonia* isolates on rice grains. Inoculum (50 cm³) was mixed to a 5-cm depth and plots were watered to prevent desiccation. Approximately 3 g per plot of wheat (*Triticum aestivum* cv. Saluda), rye (*Secale cereale* cv. Abruzzi), or oat (*Avena sativa* cv. Yeats) seed were planted in the fall of 1994 and 1995 as winter cover crops; there also was a fallow treatment. Cover crops were cut back to approximately 5 cm in height on 20 April 1995 and 22 April 1996 and sprayed with glyphosate. Residue was incorporated into soil in one half of the plots at planting, and peanuts were planted into the killed stubble in the remaining plots. Thus, inoculum, cover crop, and tillage treatments were arranged in a complete factorial treatment design. The experimental design was a randomized complete block with eight replications. Plots were planted with NC 7 on 22 May 1995 and 14 May 1996, then thinned after emergence to establish final stands of four plants per plot. Treatments were established in the same plots in both years. Standard cultural practices were used throughout the growing season (24). The incidence of pod rot was determined in each plot at digging by counting numbers of healthy and rotted pods. Plants in a few plots did not produce pods and these plots were not included in analysis of variance of disease incidence means.

RESULTS

All five pathogens were isolated during each year of the field survey; however, *Rhizoctonia* spp. predominated in 1994 and *Pythium* spp. predominated in 1995 and 1996 (Table 1). Isolation of at least one of the pathogens were obtained from 59% of pods in 1994, 65% of pods in 1995, and 75% of pods in 1996 (Table 2). In 1994, *Rhizoctonia* spp. were identified from 26% of assayed pods, *Pythium* spp. from 25% of pods, *C. parasiticum* from 17% of pods, *Sclerotium rolfsii* from 2% of pods, and *Sclerotinia minor* from 1% of pods (Table 2). Combinations of pathogens were identi-

Table 1. Number of peanut fields surveyed in North Carolina from 1994 to 1996 in which *Pythium* spp., *Rhizoctonia* spp., or *Cylindrocladium parasiticum* predominated

Predominant fungus ^a	1994	1995	1996
<i>Pythium</i> spp.	5	41	45
<i>Rhizoctonia</i> spp.	7	7	9
<i>C. parasiticum</i>	3	8	1
Total fields	15	55	55

^a Fungus most frequently isolated from a sample of 50 pods per field

Table 2. Fungi recovered from pods with pod rot symptoms in a survey of peanut fields in North Carolina

Pathogen	Percentage of pods assayed ^a		
	1994 ^b	1995 ^c	1996 ^c
<i>Pythium</i> spp.	25	44	61
<i>Rhizoctonia</i> spp.	26	20	22
<i>Cylindrocladium parasiticum</i>	17	16	6
<i>Sclerotium rolfsii</i>	2	<1	1
<i>Sclerotinia minor</i>	1	<1	<1
Multiple species	12	14	15
Total positive isolations	59	65	75

^a A total of 50 pods per field were assayed for all pathogens.

^b A total of 15 fields in six counties were surveyed.

^c A total of 55 fields in 11 counties were surveyed.

Table 3. Number of symptomatic pods yielding multiple pathogen species in surveys of peanut fields in North Carolina from 1994 to 1996

Isolate combination	1994	1995	1996
<i>Pythium</i> spp. with:			
<i>Rhizoctonia solani</i>	25 ^a	209 ^b	282 ^b
<i>Cylindrocladium parasiticum</i>	30	127	81
<i>Sclerotinia minor</i>	0	1	1
<i>Sclerotium rolfsii</i>	2	0	1
<i>R. solani</i> + <i>C. parasiticum</i>	5	22	7
<i>R. solani</i> + <i>S. minor</i>	1	1	0
<i>R. solani</i> + <i>S. rolfsii</i>	0	1	1
<i>C. parasiticum</i> + <i>S. rolfsii</i>	0	0	4
<i>Rhizoctonia</i> spp. with:			
<i>C. parasiticum</i>	20	32	4
<i>Sclerotinia minor</i>	5	1	0
<i>Sclerotium rolfsii</i>	4	2	0
<i>C. parasiticum</i> + <i>S. rolfsii</i>	0	0	2
<i>Pythium</i> + <i>C. parasiticum</i> + <i>S. rolfsii</i>	0	0	1
Total pods with combinations	92	396	399

^a Number of pods out of 750 pods assayed.

^b Number of pods out of 2,750 pods assayed in each year.

fied from 12% of pods, with *Pythium* spp. + *C. parasiticum* the most frequently isolated combination (Table 3). The next most frequent combination of pathogens consisted of isolates of *Pythium* and *Rhizoctonia*.

Of the *Pythium* isolates stored in 1994, 17 yielded viable cultures in 1996. Of these, 15 isolates were identified as *P. irregulare* and one isolate as *P. myriotyllum*; the remaining isolate could not be identified to species.

In 1995 and 1996, isolates of *Pythium* and *Rhizoctonia* continued to be the fungi most frequently isolated from symptomatic pods (Table 2). *Pythium* spp. were isolated about twice as often in 1995 as *Rhizoctonia* spp. and this trend continued in 1996, when *Pythium* isolations were about three times as frequent as isolations of *Rhizoctonia*. Combinations of pathogens were isolated from 14% of pods in 1995 and 15% in 1996. The most common combination consisted of isolates of *Pythium* and *Rhizoctonia*, and the next most common was *Pythium* spp. + *C. parasiticum* (Table 3).

Of the 109 *Pythium* isolates examined from 1996 samples, 64 were *P. irregulare* and 39 were *P. spinosum*. *P. irregulare* was found in rotted pods from 65% of the fields surveyed and *P. spinosum* was found in 41% of the fields. One isolate each of *P. dissotocum*, *P. ultimum*, *P. vexans*, *P. dimorphum*, and *P. paroecandrum* was identified, and one isolate could not be identified to species.

In 1995, estimated incidence of pod rot symptoms ranged from <1 to 25% across the 55 farms; the average incidence observed for all fields surveyed was 6.6%. Mean pod rot incidence was 5.9% in 1996, but a few farms had very high incidence of pod rot symptoms ranging from 25 to 50%.

Cotton and corn were the rotation crops most frequently identified in the 1996 survey, accounting for 27 (cotton) and 13

(corn) of the 43 fields where the previous crop was known. Mean pod rot incidence or mean percent recovery of *Rhizoctonia* spp., *Pythium* spp., or *C. parasiticum* from symptomatic pods did not differ following these crops ($P = 0.05$). Use of the foliar fungicide tebuconazole (Folicur, Bayer Corp., Kansas City, MO) also did not consistently affect these variables in fields where it was applied at least once for leaf spot control in 1995 or 1996.

There were no significant ($P = 0.05$) correlations between recovery of *Pythium* spp., *Rhizoctonia* spp., or *C. parasiticum* in 1994 or 1995. Estimated pod rot incidence in 1995 also was not correlated with recovery of these species. Recovery of *Rhizoctonia* spp. was negatively correlated ($r = -0.38$, $P < 0.01$, $n = 55$) with recovery of *Pythium* spp. in 1996 (Table 4). Product-moment correlations between pathogen or disease variables and soil factors were

moderately to very low in 1996 (Table 4). Significant positive correlations were found between recovery of *Rhizoctonia* spp. and concentration of calcium and total cations. Pod rot incidence was positively correlated with potassium concentration and buffer acidity and negatively correlated with pH.

Principal components analysis yielded similar results (Table 5). The first principal component was strongly associated with soil cations and accounted for 29% of the variability in the data. Recovery of *Rhizoctonia* spp., with a loading of 0.38, was the only pathogen variable that had any correlation with this component. The second principal component described acid chemistry (buffer acidity, base saturation, and pH), with potassium concentration and pod rot incidence also having high loadings on this factor. Estimated pod rot incidence varied positively with potassium concen-

Table 5. Principal components analysis of soil chemical factors, pod rot incidence, and fungi recovered from symptomatic pods grown in 55 peanut farms in North Carolina in 1996

Variable	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
P	-0.23	0.22	0.42	-0.55	0.26
K	0.57	0.55	0.02	-0.07	0.01
Ca	0.97	-0.06	0.08	-0.02	0.02
Mg	0.89	0.00	-0.14	0.09	0.08
Bulk density	-0.36	-0.45	0.36	-0.53	0.29
pH	0.59	-0.66	0.12	-0.02	0.05
Buffer acidity	-0.02	0.85	-0.19	-0.16	-0.03
Total cations	0.99	0.00	0.04	0.01	0.02
CEC	0.92	0.31	-0.04	-0.06	0.01
Base saturation	0.55	-0.73	0.13	0.15	0.08
Mn	-0.09	0.02	0.26	0.53	-0.58
Zn	0.16	0.23	0.82	-0.02	0.02
Cu	-0.15	0.21	0.77	0.33	-0.18
Humic matter	0.49	0.41	0.47	-0.14	0.10
<i>Pythium</i> spp.	-0.09	0.15	0.08	0.60	0.34
<i>Cylindrocladium</i> spp.	0.08	0.04	-0.19	0.40	0.59
<i>Rhizoctonia</i> spp.	0.38	-0.19	-0.16	-0.46	-0.48
Pod rot	0.05	0.56	-0.32	-0.07	0.00
Eigenvalue	5.17	3.00	1.80	1.23	0.97
Proportion	0.29	0.17	0.12	0.10	0.07
Cumulative	0.29	0.45	0.57	0.67	0.74

Table 4. Means and product-moment correlations of soil chemical factors with pod rot incidence and fungi recovered from symptomatic pods collected from 55 peanut fields in North Carolina^a

Soil factor	Mean	<i>Pythium</i> spp.	<i>Cylindrocladium</i> spp.	<i>Rhizoctonia</i> spp.	Pod rot
P mg/dm ³	143.38	-0.05	-0.18	-0.06	0.06
K meq/100 cm ³	0.25	-0.05	0.10	0.12	0.37 **
Ca meq/100 cm ³	2.57	-0.04	0.00	0.36 **	0.02
Mg meq/100 cm ³	0.44	-0.02	0.13	0.23	0.00
Bulk density g/cm ³	1.39	-0.19	-0.16	-0.04	-0.29 *
pH	5.83	-0.19	0.05	0.28 *	-0.36 **
Buffer acidity meq/100 cm ³	0.79	0.00	-0.03	-0.12	0.36 **
Total cations meq/100 cm ³	3.29	-0.03	0.04	0.33 *	0.04
CEC meq/100 cm ³	4.05	-0.04	0.02	0.27 *	0.17
Base saturation %	79.98	-0.02	0.10	-0.26	-0.28 *
Mn mg/dm ³	11.33	0.09	-0.07	-0.11	-0.06
Zn mg/dm ³	1.54	-0.01	-0.01	-0.04	-0.03
Cu mg/dm ³	1.74	0.22	-0.07	0.22	-0.11
Humic matter g/cm ³	0.77	-0.03	-0.02	0.04	0.05
<i>Pythium</i> spp. ^b	61	1.00	0.13	-0.38 **	0.02
<i>Cylindrocladium</i> spp.	6	...	1.00	-0.23	0.15
<i>Rhizoctonia</i> spp.	22	...	...	1.00	0.11
Pod rot %	6	...	...	...	1.00

^a Significant correlation coefficients are indicated by ** = $P \leq 0.01$ and * = $0.01 < P \leq 0.05$.

^b Percentage of symptomatic pods yielding indicated species.

tration and buffer acidity and negatively with pH and base saturation. Disease variables had relatively high loadings on the fourth and fifth principal components, which accounted for 17% of the total variability. Except for phosphorous and manganese content, soil chemical factors generally had very low loadings on these two components. Factor loadings for recovery of isolates of *Pythium* and *Rhizoctonia* were of opposite sign on each of the five factors retained in the final analysis.

In the 1995 microplot study, winter cover crops (wheat, oat, rye, and fallow soil) did not affect pod rot incidence, but pod-rot symptoms were enhanced in no-till treatments compared to plots with conventional tillage (Table 6). Pod rot incidence did not differ among infestation treatments, and no interactions among pathogen, cover crop, or tillage treatments were significant. In contrast, significant ($P = 0.04$) interactions among winter cover crops and tillage occurred in 1996 (Table 6). Tillage did not affect pod rot incidence following oats or wheat but, following rye, incidence was much greater in no-till than in tilled plots. The highest incidence of pod rot among all treatments was found in conventional till plots after winter fallow (Table 6).

DISCUSSION

Pod rot was found in all 11 of the major peanut-producing counties of North Carolina, and all five of the suspected pod rot fungi were isolated in each year. *Pythium* spp. and *Rhizoctonia* spp. were the fungi most frequently isolated from symptomatic pods during all 3 years of the survey. As previously described by Garren (13), pod rot was not accompanied by aboveground or root symptoms. *C. parasiticum* was isolated frequently, even though plants with obvious *Cylindrocladium* black rot symptoms on shoots, crowns, or roots were avoided during sampling. *Sclerotium rolfsii* causes extensive pod rot without conspicuous stem and crown symptoms under some conditions (22), but isolation of this fungus was relatively rare.

As many as four of the pod rot pathogens assayed were found in a given location. Several pods yielded more than one fungal species, which may have increased the rotting potential of individual pathogens (9). Conversely, antagonism between

P. myriotylum and *R. solani* has been demonstrated in sequential inoculations of peanut pods (10). Although *Rhizoctonia* spp. + *Pythium* spp. was the most frequently isolated combination overall, the rates of recovery of these fungi were negatively correlated, suggesting that antagonism may have occurred. It also is possible that differences in occurrence were related to specific adaptations to different environments by these fungi.

Recovery of *Rhizoctonia* spp. remained relatively constant during the survey period, but recovery of *Pythium* spp. increased over the years of this study. Seasonal differences in weather, especially Hurricanes Fran and Bertha in 1996, may have contributed to this trend. Other possibilities include the introduction of tebuconazole for leaf spot control in 1996, which could have suppressed *Rhizoctonia* spp. (3) and thereby enhanced recovery of *Pythium* spp. (10). Comparisons of treated and untreated fields did not provide convincing support for this hypothesis, however.

While a variety of cropping systems are used in the Virginia-Carolina production area, peanuts often are grown every third year in rotation with corn and cotton. Cotton supplanted the use of soybeans in these rotations during the 1990s, but we found little evidence that use of cotton rotations was a factor in pod rot incidence or pathogen recovery.

The general prevalence of *Pythium* spp. over *Rhizoctonia* spp. in the current surveys agrees with historic reports from the Virginia-Carolina region (14). In controlled inoculations, *P. myriotylum* is a more aggressive pathogen of pods than *R. solani* (10,14). Reports that metalaxyl suppresses pod rot in the southwestern United States likewise suggest that *Pythium* spp. can be an important cause of pod rot there (7).

Calcium deficiency can cause an abiotic disorder leading to pod rot symptoms (5). Low calcium levels were not correlated with high pod rot incidence or pathogen recovery in this survey, perhaps because nearly all growers in North Carolina apply at least 1,000 kg/ha CaSO_4 to fields each year peanuts are grown. Elevated potassium and magnesium levels in soil increase susceptibility to pod rot by competing with calcium ions (5), and both elements were

positively correlated with pod rot incidence or pathogen recovery in the principal component analysis. Thus, some growers in North Carolina may still have fields with nutrient imbalances leading to development of pod rot, despite high levels of calcium application.

Wright and Porter (28) found that peanut yields were lower under no-till production than under conventional tillage, and other observations suggested that high levels of pod rot could explain yield losses in some cases. If so, the small grain species used as a cover crop could be an important influence on populations of *Pythium* and its antagonists. Rye in particular is susceptible to *P. myriotylum* (18) and its use as a cover crop before peanut is discouraged. However, the cover crop by tillage experiments did not show consistent effects of either factor on pod rot incidence. Highest levels of pod rot were found when peanuts were planted after winter fallow in conventionally tilled plots in 1996. Working in peanut fields in Israel, Frank (8) found that *Pythium* populations were maintained at high levels after weedy winter fallow and were reduced after clean summer fallow.

We could not specifically address whether pod rot losses have increased recently because similar studies have not been conducted over decades. Reports from the 1960s and 1970s estimated losses of 20% on a state-wide basis (26,27), and studies published during that period reported 10 to 15% pod rot incidence in untreated controls (12,15). In contrast, we estimated overall disease incidence of approximately 6% in 1995 and 1996, with isolated cases of extremely high incidences (25 to 50%) in individual fields. In some fields, we may have underestimated pod rot incidence because of pod shedding before digging.

The most striking difference found in comparing the results of this study with historical reports was the paucity of *P. myriotylum* isolations. Although *P. ultimum*, *P. debaryanum*, *P. irregulare*, and other unidentified *Pythium* spp. have been implicated in pod rot (2,7,16), previous investigations focused on *P. myriotylum*. The isolation methods we used (for example, incubation at room temperature) may have not favored recovery of this species. Only fast-growing isolates, which should

Table 6. Effects of tillage and cover crops on incidence of peanut pod rot in microplots infested with isolates of *Pythium* or *Rhizoctonia*

Cover crop	1995 ^a			1996 ^b		
	Conventional tillage	No tillage	Mean	Conventional tillage	No tillage	Mean
Oat	7.5	8.5	8.0	7.1	7.5	7.3
Wheat	5.6	7.5	6.6	8.9	7.5	8.2
Rye	6.2	9.6	7.9	3.7	13.2	8.6
None	5.3	8.7	7.0	17.7	10.4	14.1
Mean	6.1	8.6		9.4	9.7	

^a Means of eight replications and four inoculum combinations. Differences in cover crop means were not significant at $P = 0.05$; tillage means were significant at $P = 0.018$. No interactions were significant at $P = 0.05$.

^b Means of eight replications and four inoculum combinations. Cover crop $\times$ tillage interaction was significant at $P = 0.04$.

have included *P. myriotylum*, were counted as positive, however. *P. irregulare* was the most frequently isolated species, and reports on peanut (16) and other hosts indicate that it can be an aggressive pathogen. Some *Pythium* isolates obtained in this survey currently are being evaluated for their pathogenicity and aggressiveness on peanut pods.

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