Population Dynamics of *Pythium* spp. in Soil Planted with Peanut

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ABSTRACT

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Populations of *Pythium* spp. in Oklahoma field soils planted with peanut had distinctive temporal patterns to their fluctuations during the growing season. Temporal patterns occurred in three different peanut-growing areas of Oklahoma in dissimilar soils planted to different cultivars. Two general types of temporal patterns were observed, both occurring after initiation of pegging and pod development. The most frequently encountered pattern was an increase in population to a maximum, followed by either a sharp or a gradual decline. The other pattern was a gradual population increase during the season, reaching a maximum at harvest. Populations of *Pythium* spp. in fallow soil in field plots at the Caddo Research Station, Ft. Cobb, Oklahoma, in 1989 and 1990 fluctuated randomly, whereas populations in adjacent plots planted to peanut peaked several weeks after pegging, then rapidly declined by harvest. The temporal pattern of the population peak and decline was re-created in growth chambers using field soil planted with peanut. In these studies, greater populations of *Pythium* spp. were found in field soil containing peanut roots and/or pods than in soil without roots and pods. At the Caddo Research Station, the frequency of isolation of *Pythium* spp. from pods increased with pod age; however, maximum isolation frequency from pods was not synchronous with the peak populations of *Pythium* spp. in soil but occurred 1-2 mo after the population peaks. These results suggest that colonization of pods by *Pythium* spp. may be regulated by pod development.

Species of *Pythium* cause serious diseases of peanut (*Arachis hypogaea* L.), including preemergence and postemergence damping-off of seed and seedlings (20) and root and pod rots (6,7,20). In particular, *P. myriotylum* Drechs. has received considerable attention because of its role in pod rot (6,20), a disease that can cause substantial economic loss in peanut production (7,20). In Oklahoma, *P. myriotylum* is routinely isolated from rotted pods (5–7,15), but other species, such as *P. aphanidermatum* (Edson) Fitzp. and *P. ultimum* Trow, also may be important pod-rotting fungi (*unpublished*).

Little was known about the population dynamics of *Pythium* spp. in soil planted to peanut until a report by Filonow and Jackson (5). While monitoring populations of *Pythium* spp. in soil that had been treated with metalaxyl and other fungicides at the Caddo Research Station, Ft. Cobb, Oklahoma, they noted a sharp rise and fall in population density of *Pythium* spp. a few weeks after pegging or about 60–90 days after planting. Metalaxyl treatment reduced the peak population. Later, Lewis and Filonow (15) observed a similar temporal pattern in populations of *Pythium* spp. in soil on the Research Station and at two other peanut fields in Oklahoma. The temporal pattern was not influenced by peanut cultivar. Neither soil temperature nor soil matric potential had any apparent effect on the temporal pattern; however, only limited measurements of these environmental variables were made. Except for these reports, little is known of the population dynamics of *Pythium* spp. in soils planted to peanut.

The objectives of this research were: 1) to further characterize a temporal pattern in populations of *Pythium* spp. in peanut soil at the Research Station at Ft. Cobb and determine if similar temporal patterns exist in fields in other peanut-growing areas of the state and 2) to investigate the role that the peanut host may have on populations of *Pythium* spp. in soil.

MATERIALS AND METHODS

Populations of *Pythium* spp. in field soil at the Caddo Research Station. The influence of peanut plants on populations of *Pythium* spp. in soil was monitored in 1989 and 1990 in the same field plots used in an earlier study (15) at the research station. In these experiments, the effect of no host (fallowed soil) and a different leguminous host on populations also was assessed. Characteristics of soil from the Ft. Cobb site are given in Table 1. Plots consisted of four rows, 10.9 m long with 0.91-m row spacings, arranged in a randomized complete block design with five replicates per treatment. Treatment was peanut (cv. Florigiant), soybean (cv. Forrest), or fallowed soil. Peanut and soybean seeds were treated with Granox PMF (Gustafson) at 3.9 cm^3/kg of seed and planted at 10 seeds per meter on 24 May 1989 and 17 seeds per meter on 15 May 1990. Except for one application of acephate (Orthene) at 265.5 cm^3/ha for thrips control in 1989, no pesticides were applied to the plots. Weeds were removed by hand. All

Table 1. Characteristics of Oklahoma field soils planted with peanut

	Separates (%)				Nutrients				
Site[a]	Sand	Silt	Clay	pH	P (kg/ha)	K (kg/ha)	Ca (kg/ha)	NO_3—N (kg/ha)	NH_4—N (μg/g)
Ft. Cobb	62	20	18	7.0	92	186	1,093	12	0.22
C4	58	22	20	6.9	141	245	1,989	27	0.23
C6	50	25	25	6.6	197	521	1,661	19	0.20
C10	56	19	25	7.4	74	138	1,131	19	0.08
G1	57	10	33	7.4	65	389	4,317	17	0.42
G2	51	12	37	5.8	112	231	2,807	20	0.37
M1	74	10	16	4.9	66	69	283	25	0.30
M2	65	20	15	6.4	202	256	998	18	0.13

[a] Ft. Cobb and fields C4, C6, and C10 are in Caddo County; fields G1 and G2 are in Garvin County; and fields M1 and M2 are in Marshall County.

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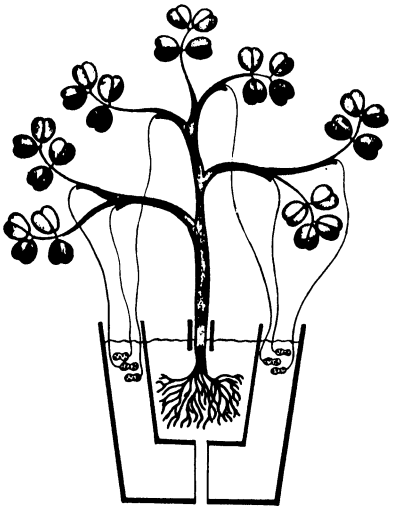

Fig. 1. Nested pot arrangement for experiments assessing the effect of roots and/or pods on populations of *Pythium* spp. in soil.

plots were irrigated with approximately 5 cm of water every 7–10 days.

Soil from each row in the plots was sampled on the day of planting and at 1- to 2-wk intervals thereafter to harvest. Three random samples per row were taken with a garden trowel to a depth of 7–10 cm and composited to obtain one sample per row. In rows with peanut or soybean plants, samples were obtained from the pegging zone or the root zone of the plants, respectively. Soil sampling of fallowed plots was from the center of rows as marked by stakes. Samples were transported to the laboratory within 8 hr and held at 5 C for 24–48 hr until soils were assayed for populations of *Pythium* spp.

Samples were thoroughly mixed and a 10-g subsample was suspended in 90 ml of sterile 0.1% (w/v) agar in water in 250-ml flasks. One 10-g sample from each bag also was air-dried at 80 C for 72 hr and reweighed to determine soil moisture. Flasks were shaken for 30 min, and populations of *Pythium* spp. in soil were estimated by plating 0.2 ml of a 1:10 or 1:50 dilution on each of five dishes (9 cm diameter) containing a *Pythium*-selective medium (15). Dishes were incubated at 23–25 C for 36-48 hr and washed under running water, and colonies were counted. Populations were expressed as propagules per gram (p/g) of oven-dried soil.

After pegging, three peanut plants were periodically selected at random in each row and uprooted to monitor colonization of pods by *Pythium* spp. Pods from sampled plants were bulked by row. Pods were washed with water and cut into 1-cm pieces, and five randomly selected pieces were plated on each of 10 dishes of *Pythium*-selective medium. Five dishes were incubated at 23–25 C and five were incubated at 38 C. After 24–48 hr, dishes were examined for colonies of *Pythium* spp. Selected colonies were subcultured and stored on cornmeal agar for identification (22).

Peanut plots were harvested at maturity with a digger-inverter and threshed with a stationary thresher. Pods from each row were bulked, washed with water, and air-dried for 48 hr at 23–25 C. Pods were stored at 5 C until rated for rot severity, where 1 = no pod rot, 2 = 1–25%, 3 = 26–50%, 4 = 51–75%, and 5 = >75% pod rot. A mean pod rot index for each row was calculated by summing the number of pods in disease indices 3, 4, and 5 (these account for most of the economic loss to pod rot) and dividing by the total number of pods (5). Isolations for *Pythium* spp. from pods were made as described above.

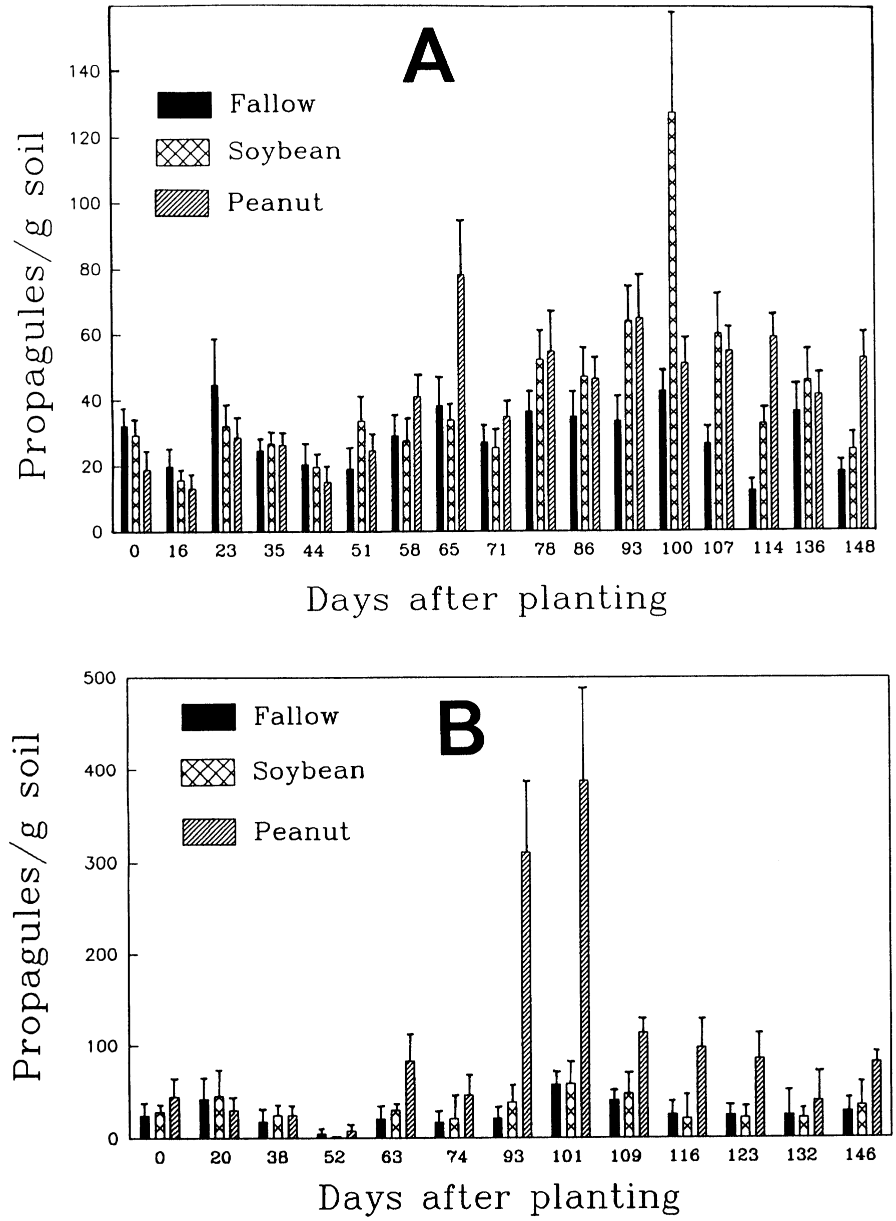

Fig. 2. Temporal populations of *Pythium* spp. in fallowed soil or in soils planted with peanut or soybean at the Caddo Research Station, Ft. Cobb, Oklahoma, in **(A)** 1989 and **(B)** 1990. Values are the means of 20 replicates ± 1 SE.

Population assessments at other field locations. Populations of *Pythium* spp. in peanut soils from seven additional fields also were monitored in 1990. Three of these were in Caddo County, two were in Garvin County, and two were in Marshall County. The fields in Caddo County were known to support pod rot caused by *Pythium* spp. (7). The other fields were chosen after preliminary population assays of soils in late May 1990 showed measurable populations (>10–20 p/g) of *Pythium* spp. The texture and nutrient contents of soil from each field also were determined (Table 1).

Fields C4, C6, and C10 in Caddo County were planted on 21 May, 18 May, and 20 May, respectively. Site C4 was planted with cv. Spanco, and C6 and C10 were planted with cv. Florunner. Fields G1 and G2 in Garvin County were planted with cv. Pronto on 15 May. Fields M1 and M2 in Marshall County were planted with cv. Okrun on 17 May. Peanut plants in field C4 were planted in sorghum stubble, and field G2 was double-row-planted (0.65-m spacings between rows). Rows in all other fields were spaced 0.9 m apart. Sampling commenced in these fields about 2–3 wk after planting, on the same day as at Ft. Cobb.

At each field, a permanent reference at a corner of the field was used to align the direction of the sampling transect. Samples were taken from each of 10 consecutive rows along the transect from the field, beginning at the 20th row from the reference point. Three random soil samples from the root and/or pegging zones (7–10 cm deep) were obtained from each row and bulked by row. Populations of *Pythium* spp. and soil moisture content of soils were determined as described above.

Samples of soils from all fields were characterized as to texture, pH, and nutrient composition by the Soil, Water and Forage Analytical Laboratory at Oklahoma State University.

Effect of peanut roots and/or pods on populations of *Pythium* spp. Experiments were conducted with Ft. Cobb soil enclosed within two nested plastic pots (Fig. 1). The inner pot was 17 cm in diameter and 18 cm in height and the outer pot was 24 cm in diameter and 28 cm in height. A piece of PVC pipe (2 cm i.d., 12 cm long) was cemented between the drain holes of each pot with silicone caulk. The pipe allowed for drainage of soil water from the inner pot without contaminating the soil in the outer pot. The outer pot had a hole for drainage.

Florigiant seed were surface-disinfested in 1.05% (v/v) sodium hypochlorite for 4 min, rinsed several times in sterile water, and incubated between sterile, moist paper towels for 3–4 days at 25 C. One germinated seed was planted in each inner pot. Nested pots were incubated in walk-in growth chambers at 26 C under 550 $\mu E \cdot m^{-2} \cdot s^{-1}$ of fluorescent light for 12 hr and under 12 hr of darkness at 24 C. At pegging (about 45 days after planting [DAP]), pegs were oriented to achieve treatments consisting of soil in the outer pot containing no pods, 50% of the pods, or all of the pods. Soil in the corresponding inner pot contained roots, roots plus 50% of pods, or roots plus 100% of the pods. Because of the indeterminate nature of pegging and the proximity of the lowest vines to the soil surface, it was difficult to quantitatively allocate pegs to the inner or outer pots to give a 50% distribution. A few pegs also were found in the roots-only zone and had to be redistributed during the experiment. In a second experiment, therefore, the 50% pod treatments were omitted and treatments were no roots or pods, roots only, pods only, and roots plus pods. In addition, seedlings were planted in soil contained in a glass cylinder (3.5 cm i.d., 15 cm long) that elevated the seedling 5–7 cm above the soil in the inner pot. This arrangement made it easier to train pegs from lower branches away from the rooting zone.

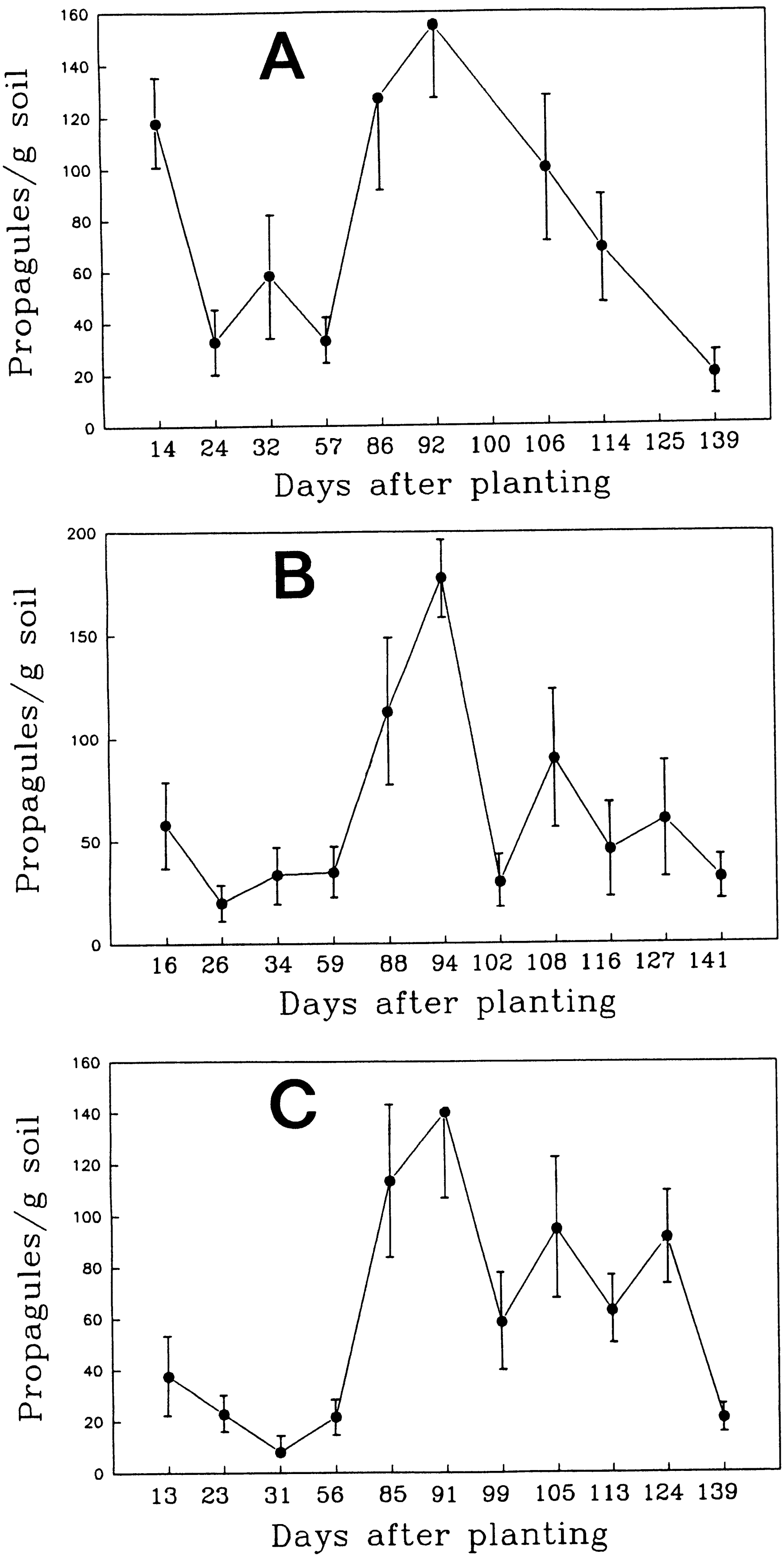

Fig. 3. Temporal populations of *Pythium* spp. in soil planted with peanut at **(A)** site C4, **(B)** site C6, and **(C)** site C10 in Caddo County, Oklahoma, in 1990. Values are the means of 10 replicates ± 1 SE.

There were six replicates per treatment in each experiment. Treatments were completely randomized within the chamber. Soil in pots was watered daily, and 25 ml of Hoagland's solution (14) was added every 2 wk to the inner and outer pots. Populations of *Pythium* spp. in soils of inner and outer pots were monitored at 30-day intervals as described previously. Each inner and outer pot was sampled once in each replicate. Each sample was the composite of three 5- to 10-g subsamples collected with a spatula. The first and second experiments were harvested at 102 and 142 DAP, respectively, and pods were examined for symptoms of pod rot. Pod pieces were plated on *Pythium*-selective medium to confirm the presence of *Pythium* spp.

Field and growth chamber data were statistically analyzed using the Costat computer program (version 3.0, CoHort Software, Berkeley, CA). Comparisons were made between populations of *Pythium* spp. in fallow, soybean, and peanut soils at specific sampling times. Data were subjected to one-way analysis of variance, and significant differences between means were determined using the Student-Newman-Keuls test. The influence of sampling date (time) on populations of *Pythium* spp. was determined by correlation. Population and time data also were subjected to polynomial and Fourier (periodic curve fitting) regression analyses. Significant differences between treatments were determined at $P \leq 0.05$.

RESULTS

Population studies at Ft. Cobb. Populations of *Pythium* spp. in fallowed soil in 1989 (Fig. 2A) varied over time without any discernible pattern or without any significant fluctuation. In 1989, populations of *Pythium* spp. in fallowed soil ranged from 12.2 to 44.9 p/g. A similar result was obtained in 1990 (Fig. 2B), with populations in fallowed soil ranging from 4.7 to 57.6 p/g. In both years, temporal populations of *Pythium* spp. in fallowed soil were not correlated ($P > 0.05$) with sampling date.

Populations of *Pythium* spp. in soil planted with soybean in 1989 (Fig. 2A) varied little over time from planting until 100 DAP, when the population (127.0 p/g) was greater than populations at other dates. A similar increase in populations of *Pythium* spp. in soybean soil was not observed in 1990 (Fig 2B); however, repeated animal feeding on soybean leaves and stems resulted in stunted plants with few pods at harvest. Populations of *Pythium* spp. in soybean soil during 1990 varied from 2 to 58.7 p/g, with no apparent temporal pattern. In both years, populations of *Pythium* spp. in soybean soil were not correlated with sampling date.

Temporal populations of *Pythium* spp. in peanut soil were characterized by distinctive peaks, which occurred after the initiation of pegging. Pegging was observed at 44 DAP in 1989 and 52 DAP in 1990. Populations in 1989 (Fig. 2A) changed little during the growing season until 65 DAP, when the population (78.1 p/g) peaked and then declined. Thereafter, populations varied only slightly in peanut soil. The peak at 65 DAP was greater ($P \leq 0.05$) than all preceding populations in peanut soil and the population at 71 DAP but not subsequent populations. Populations of *Pythium* spp. in peanut soil in 1990 (Fig. 2B) changed little over time until 93 DAP, when the population increased to 311.2 p/g soil. The population continued to increase, reaching a maximum (388.5 p/g) at 101 DAP; thereafter, populations declined. Populations at 93 and 101 DAP did not differ ($P \leq 0.05$), but both were greater than all other populations in peanut soil. Populations in soil were significantly correlated ($R = 0.66$, $P = 0.05$) with sampling date in 1989 but not in 1990. Populations in 1989 were related to time by the model $y = 7.42 + 0.79x - 0.003x^2$ ($r^2 = 0.55$, $P = 0.004$).

Soils cropped with peanut or soybean plants had greater ($P \leq 0.05$) populations of *Pythium* spp. within a season than fallowed soils. Mean seasonal populations in peanut soil were not greater than those in soybean soil in 1989, but they were greater ($P \leq 0.05$) in 1990. The effect of host plant on populations also was compared at specific sampling dates during a season. In 1989, there were few differences between weekly populations of *Pythium* spp. in the various soils until 65 DAP, when the *Pythium* population in peanut soil was greater ($P \leq 0.05$) than

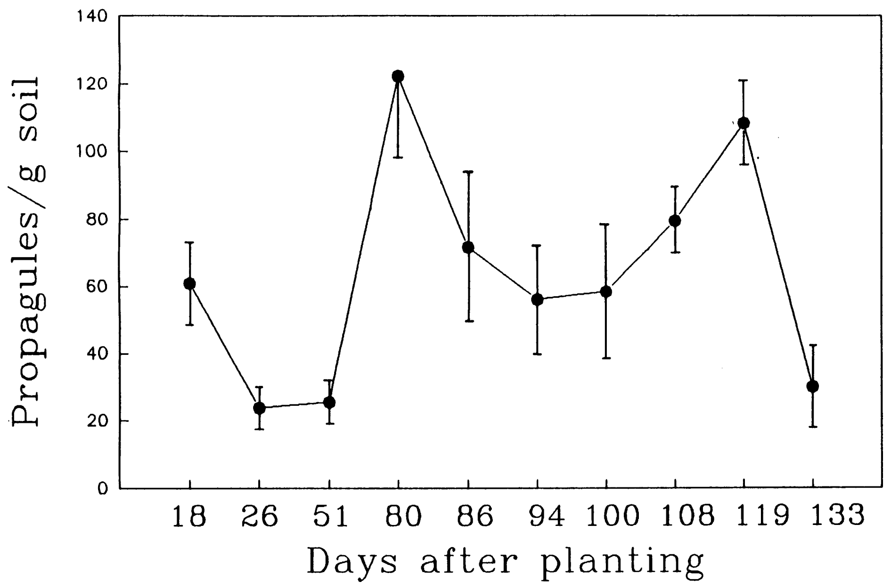

Fig. 4. Temporal populations of *Pythium* spp. in soil planted to peanut at site G1 in Garvin County, Oklahoma, in 1990. Values are the means of 10 replicates ± 1 SE.

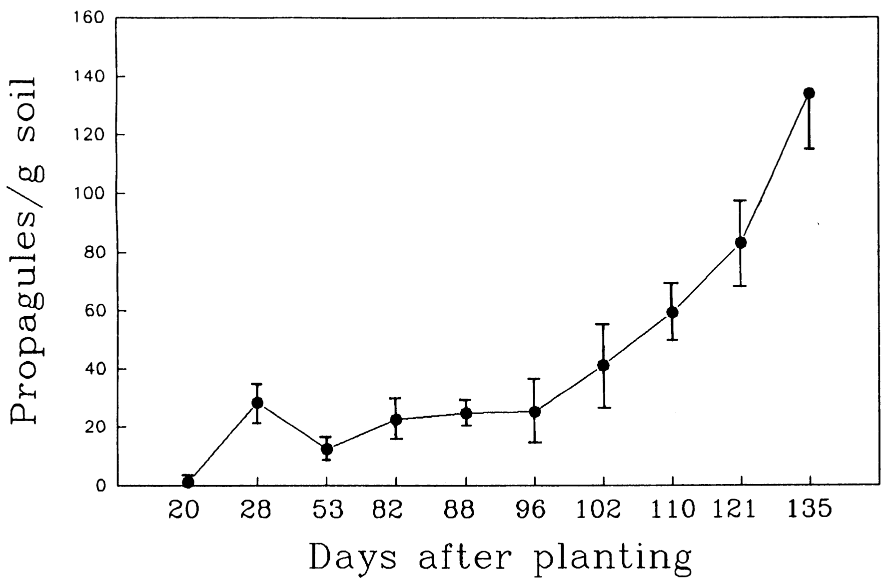

Fig. 5. Temporal populations of *Pythium* spp. in soil planted to peanut at site M1 in Marshall County, Oklahoma, in 1990. Values are the means of 10 replicates ± 1 SE.

populations in fallow or soybean soil (Fig. 2A). Thereafter, populations in fallowed soil were generally lower than those in peanut or soybean soil. At 100 DAP, the population in soybean soil was greater ($P \leq 0.05$) than that in peanut or fallow soil.

Few differences between the 1990 populations were observed until 63 DAP, when populations in peanut soil peaked ($P \leq 0.05$) (Fig. 2B). Populations of *Pythium* spp. were generally greater ($P \leq 0.05$) in peanut soil than in soybean or fallowed soil at individual sampling dates from 93 to 146 DAP (harvest).

Pod rot was severe in the peanut plots at harvest. The mean pod rot severity index for all plots in 1989 and 1990 was 3.93 and 3.94, respectively. Recovery of *Pythium* spp. from newly developed pods (R3 reproductive stage [3]) was very low but increased as pods matured from stage R4 (full pod) to stage R8 (harvest). Isolation of *Pythium* spp. from peanut pods increased as the growing season progressed. In 1989, mean isolation frequency was 1.6, 16.8, 49.8, and 50.2 at 65, 78, 114, and 148 DAP (harvest), respectively. In 1990, isolation frequencies were 16.3, 21.8, 37.2, and 42.6 at 74, 93, 116, and 146 DAP (harvest), respectively. Of the *Pythium* spp. isolated from pods at harvest, 42–46% were identified as *P. myriotylum* (22).

Populations of *Pythium* spp. in other fields. Soil populations of *Pythium* spp. in other peanut fields also had discernible patterns to fluctuations over time. In Caddo County, pegging was observed at site C4, C6, and C10 at 57, 59, and 56 DAP, respectively. At site C4 (Fig. 3A), the population was high (118 p/g) in the first soil sample but had declined markedly 1 wk later. There was a small but nonsignificant increase in population at 32 DAP, but the maximum ($P \leq 0.05$) population (155.3 p/g) occurred at 92 DAP. Thereafter, populations steadily declined. The population of *Pythium* spp. in soil at site C6 (Fig. 3B) was significantly greater (177.8 p/g) at 94 DAP than at all other sampling dates; a smaller peak occurred at 108 DAP. At site C10 (Fig. 3C), populations increased to 113.7 and 140.3 p/g at 85 and 91 DAP, respectively, after which they waxed and waned until harvest. Populations at 85 and 91 DAP did not differ ($P \leq 0.05$), but they were greater than all preceding populations and the populations at 99, 113, and 139 DAP.

In Garvin County, pegging was observed at both sites at 51 DAP. Populations of *Pythium* spp. at site G1 (Fig. 4) significantly peaked at 80 DAP (122.4 p/g) and again at 119 DAP (108.4 p/g), near the end of the growing season. Dual population peaks were not observed during the growing season at site G2 (*data not shown*). Population dynamics of *Pythium* spp. at G2 were similar to those at C6.

The pattern of temporal change in soil populations of *Pythium* spp. in fields of Marshall County was much different from those observed in Caddo and Garvin counties. Mid- or late-season peaks were not observed. Populations of *Pythium* spp. at site M1 (Fig. 5) progressively increased over the season, reaching 136.2 p/g at harvest. This population was significantly greater than all preceding populations. A similar pattern of population dynamics was observed at M2 (*data not shown*), with a population of 54.7 p/g at harvest. This population was not significantly different from preceding populations because of the considerable variation in populations at each sampling. Pegging at sites M1 and M2 was observed at 82 DAP and harvest was at 135 DAP.

Except at site M1, where soil populations of *Pythium* spp. were correlated ($R = 0.607$, $P = 0.05$) with sampling time, no significant correlations between populations and time were found in any of these fields. At site M1, populations were related to time by the model $y = 49.90 - 1.95x + 0.02x^2$ ($r^2 = 0.94$, $P = 0.001$).

Effect of peanut roots and/or pods on *Pythium* spp. populations. Populations of *Pythium* spp. in soil without roots and pods varied from 23.4 to 48.7 p/g in the first experiment and from 17.4 to 23.2 p/g in the second experiment. Populations showed no significant fluctuations over time (Fig. 6). In soil containing only roots, populations were 23.3, 104.9, 138.2, and 67.5 p/g at 0, 79, 94, and 102 DAP, respectively, in the first experiment. The population peak at 94 DAP was significantly different from populations at 0 and 102 DAP but not at 79 DAP. During the first experiment, several pegs and small pods were found in the roots-only zone. These were pulled and reestablished in the pod zone. In a second experiment, no pegs entered the roots-only zone and populations of *Pythium* spp. did not significantly fluctuate over time (Fig. 6). Populations in soil containing only pods were 25.3, 108.0, 54.3, and 59.7 p/g at 0, 79, 94, and 102 DAP, respectively, in the first experiment. The population at 79 DAP was significantly greater than populations at all other sampling dates. The population also significantly peaked (82.7 p/g) in soil containing pods in the second experiment, but at 119 DAP (Fig. 6). Pod rot was found in both experiments.

The peak and decline pattern of population dynamics observed in soil containing pods was also observed in soil containing roots and pods. In one experiment, populations increased from 23.2 p/g at planting to a maximum ($P \leq 0.05$) of 177.1 p/g at 79 DAP. Thereafter, the populations decreased to 91.6 and 71.7 p/g at 94 and 102 DAP, respectively. In a second experiment (Fig. 6), populations of *Pythium* spp. significantly peaked (119.3 p/g) at 89 DAP and tended to stay high up to harvest.

DISCUSSION

Our results from experiments at the Caddo Research Station corroborate those of others (5,15) who previously had reported a proliferation in populations of *Pythium* spp. after pegging, followed by a rapid decline by harvest in soil planted to peanut. In addition, the temporal occurrence of the peaks and their populations found at the research station in our study were similar to those observed by previous researchers (5,15).

This population phenomenon was not restricted to the research station. In our study, populations of *Pythium* spp. in fields of Caddo County at Albert (C10), Hinton (C6), and another Ft. Cobb site (C4) increased to a maximum at about 90 DAP and gradually declined by harvest. Similar population dynamics were observed in peanut fields in Garvin County. At site G1, however, two distinctive population peaks were recorded during the season. Nevertheless, popula-

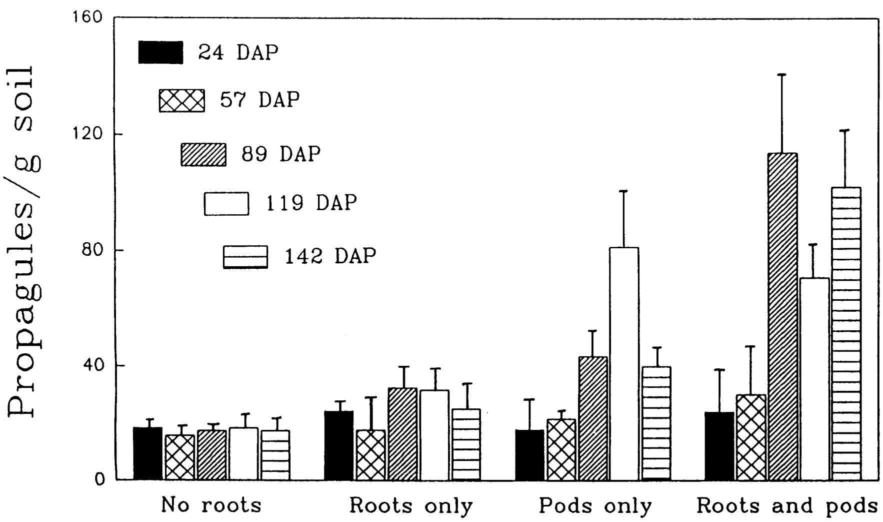

Fig. 6. Effect of peanut roots and/or pods on populations of *Pythium* spp. in soil. Values are the means of six replicates ± 1 SE.

tions had declined before harvest. Therefore, the proliferation and decline population effect has occurred over several years in soils of dissimilar textures and chemical characteristics planted to different cultivars and located in different areas of Oklahoma.

At Marshall County field sites (M1 and M2), however, a different temporal pattern in population fluctuations of *Pythium* spp. was observed. After pegging, populations in these fields progressively increased and reached maximums at harvest. A population pattern similar to that at M1 and M2 was recorded in 1987 in a different field in Marshall County (15). Although this pattern of temporal fluctuation is distinctly different from the pattern of population proliferation and decline, it is not the only pattern found in peanut fields in Marshall County. A proliferation and decline pattern also has been recorded in Marshall County (15).

Our results and those of others (5,15) indicate that the population dynamics of *Pythium* spp. in soil planted with peanut fluctuate according to distinctive patterns. Although we have discovered two such patterns, others may exist. Additional studies are needed to determine the commonality of these patterns to peanut fields in Oklahoma and other peanut-producing areas of the United States.

Plant hosts may influence population dynamics of *Pythium* spp. in soil (13). Populations of *Pythium* spp. in soil cropped to a rough grass meadow in England showed temporal periodicity in 1983; in 1984, however, no peaks were found in the same plots (12). In a longer study in England, Ali-Shtayeh et al (2) observed a winter peak and a summer trough in populations of total *Pythium* spp. in soil. Periodicity in population fluctuations were best explained by a sine curve model. Using Fourier regression analysis, we found no significant periodicity in the population dynamics during the growing season in the peanut fields we studied. Several researchers (1,16) have reported greater population levels of *Pythium* spp. in soils during winter months than in spring or summer months. Soil populations of *P. ultimum* in California cotton fields were greater in the autumn, winter, and spring than in August or early September (11). Others (19) have found no general pattern in population dynamics of *Pythium* spp. in soil.

The peanut host greatly influenced the population dynamics of *Pythium* spp. in soil. Results from our studies support this conclusion. Mean seasonal populations in fallowed soil at the Caddo Research Station in Ft. Cobb were severalfold lower than those in soybean or peanut fields, and populations in fallowed soil varied over time without pattern. Populations in soils planted to peanut, however, peaked and declined during the growing season. In soils planted with soybean, a significant peak in population was found in the 1989 experiment, but at a later date in the growing season than the peak population in peanut soil. Animal feeding in 1990 restricted soybean growth so that the photosynthetic capacity of these stunted plants and the rhizosphere effect (4) were most likely reduced, and no population peak was found. None of the other peanut fields monitored had soil populations of *Pythium* spp. that appeared random in their temporal fluctuations. All had some discernible pattern to their population dynamics.

In growth chamber studies, soil without peanut roots and pods had populations of *Pythium* spp. that were low and varied without obvious pattern over the course of the experiments, similar to fallowed field soil. Populations in soil containing roots and/or pods, however, typically showed one or more population peaks that were generally higher than populations in soil without plant tissue at the same sampling dates. Moreover, these experiments suggested that peanut roots may exert a different effect than pods on populations of *Pythium* spp., as indicated by the occurrence of population peaks at different times for soil containing roots than for soil containing pods. In addition, results from these studies suggest that pods alone influence the temporal fluctuation of populations of *Pythium* spp. in peanut soil, as shown by the significant population peaks that occurred in the pods-only soil in both experiments.

Other researchers (8,17) have noted fungal increases in the geocarposphere. Hale (9) and Hale and Griffin (10) showed that developing pods exuded sugars and that nutrient exudation decreased as pods developed and matured (9). Other researchers (18,21) also reported this relationship between pod maturation and leakage of nutrients. Using these findings, Lewis and Filonow (15) postulated a mechanism to account for the population peak and decline effect observed in peanut fields. They (15) reasoned that as pods develop in soil, leaked nutrients could be used to support a proliferation of microorganisms in the geocarposphere, including propagules of *Pythium* spp. After pods had developed and nutrient leakage dwindled, energy-deprived microorganisms may colonize and lyse propagules of *Pythium* spp., resulting in a population decline.

The decline in populations of *Pythium* spp. in soil after the peak also may be accounted for by hyphae of *Pythium* spp. moving from soil to colonize pod surfaces, thereby lowering soil populations. Our results from the Caddo Research Station tend to support this hypothesis for the decline phase. Recovery of *Pythium* spp. from pods as they developed during the season was not synchronous with the increase in soil populations of *Pythium* spp. leading to the peaks. Maximum recovery of *Pythium* spp. from pods occurred 1–2 mo after the maximum population of *Pythium* spp. in soil. Thus, recovery of *Pythium* spp. from pods was increasing while recovery from soil was decreasing, suggesting movement from soil on to pods. Further studies are needed to elucidate the mechanism(s) accounting for the patterns of population dynamics observed to date.

In summary, populations of *Pythium* spp. in Oklahoma soils planted to peanut showed distinctive patterns in their temporal fluctuations during the growing season that were related to the presence of the peanut plant. Further studies relating peanut phenology in the field with the population dynamics of *Pythium* spp. may aid the management of peanut root and pod diseases caused by *Pythium* spp.

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