Physiologic Races of *Phytophthora megasperma* f. sp. *glycinea* in Indiana, 1973–1979

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ABSTRACT

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More than 1,000 isolates of *Phytophthora megasperma* f. sp. *glycinea* were collected during yearly surveys of soybean fields in Indiana from 1973 through 1979, and the physiologic race of each isolate was determined. Before 1973, only race 1 was found in Indiana, and it was found in most parts of the state. New races were found in 22 counties in the central and northern parts of the state. Race 3 comprised 48% of all isolates, followed by race 7 (18%), race 1 (17%), race 9 (12%), race 4 (3%), race 8 (2%), race 5 (0.2%), and race 13 (0.1%). The other eight described races were not found. The effect of resistant cultivars on the occurrence of new races of the pathogen is discussed.

Phytophthora root rot of soybean (*Glycine max* (L.) Merr.), incited by *Phytophthora megasperma* f. sp. *glycinea* Kuan & Erwin (5) (syn. *P. megasperma* (Drechs.) var. *sojae* A. A. Hildeb. [3]), was first reported in 1955 (11), although the disease was observed in Indiana in 1948 and in Ohio in 1951. Phytophthora root rot became the most destructive soybean disease in Indiana, particularly on the heavy, poorly drained soils in the central and northern parts of the state.

Resistant cultivars were identified, and resistance to the pathogen was shown to be controlled by the single, dominant gene *Ps* (1), now designated Rps_1 (8). Resistant cultivars with this gene developed for the Midwest include Harosoy 63, Hawkeye 63, Lindarin 63, Clark 63, Chippewa 64, Beeson, Calland, Protana, Amsoy 71, Cutler 71, Wells, Oakland, and Century.

A second physiologic race of the fungus was found in Mississippi in 1965 (7). However, race 2 was avirulent to cultivars with the Rps_1 gene. These cultivars remained resistant until 1972, when race 3 of the pathogen was found in Ohio (9). In 1974, race 4 was described in Kansas (10). Races 5 and 6 were reported in 1976 from Ontario, Canada (2).

In July 1975, plant pathologists and plant breeders interested in Phytophthora root rot of soybean adopted a uniform set of soybean differentials at a meeting in Harrow, Ontario. The set consisted of Harosoy, Harosoy 63, Sanga, Mack, Altona, PI 103091, and PI 171442. The addition of PI 103091 and PI 171442 enabled researchers to discriminate races 7–9 from among a large group of isolates previously classified as race 6 (6). Races 10–16 were reported from Mississippi in 1979 (4).

We identified the physiologic race of 1,100 isolates of *P. megasperma* f. sp. *glycinea* collected between 1973 and 1979. We report here the distribution and prevalence of these races in Indiana.

MATERIALS AND METHODS

Dying plants suspected of being infected with *P. megasperma* f. sp. *glycinea* were collected throughout Indiana, but primarily in the central and northern parts of the state, where Phytophthora root rot is most severe. A portion of the basal stem 10–12 cm long consisting of diseased and healthy tissue was placed in a plastic bag and kept on ice until it was sectioned. Four or five cross sections were taken from the transition area between diseased and healthy tissue and were aseptically transferred to a selective medium in single petri plates. The medium consisted of 0.6 g of $CaCO_3$, 0.2 g of Bacto yeast extract, 1 g of sucrose, 0.01 g of cholesterol, 0.002 g of benomyl (Benlate), 0.027 g of terrachlor (pentachloronitrobenzene), 0.2 g of vancomycin (hydrochloride), 20 g of agar, 40 ml of V-8 juice, and 1,000 ml of water. Generally, one uncontaminated isolate from each plate was transferred and maintained on potato-dextrose agar slants at 20–24 C in an unlighted cabinet.

Inoculum was prepared by growing the isolates on oatmeal agar in petri plates in an unlighted cabinet for 2–3 wk at 24 C. Inoculations were made by the standard hypocotyl method: a 2 × 2 mm piece of mycelium was inserted into a longitudinal slit in the hypocotyl, and the wound was covered with petrolatum to prevent desiccation of the inoculum and host tissue. Ten 10-day-old seedlings of each soybean differential were inoculated with each isolate and grown in the greenhouse at 24–27 C with supplemental fluorescent and incandescent light. Harosoy and Tracy were included as universally susceptible and resistant controls, respectively. Six days after inoculation, the seedlings were classified as susceptible (dead) or resistant (no external symptoms) to the isolate.

RESULTS AND DISCUSSION

The percentage of isolates of each race in each year is shown in Table 1. Nearly half the isolates were race 3, followed in order of prevalence by races 7, 1, 9, 4, 8, 5, and 13. Until 1973, only race 1 had been found in Indiana, and it was found in most parts of the state. Only 17% of the isolates we obtained since 1973 were race 1, indicating the effect of cultivars that have the gene Rps_1 and are resistant to races 1 and 2 of the pathogen.

Table 1. Physiologic race of isolates of *Phytophthora megasperma* f. sp. *glycinea* from soybean collected in Indiana, 1973–1979

Year	Physiologic race 1 (%)	3 (%)	4 (%)	5 (%)	7 (%)	8 (%)	9 (%)	Total (no.)
1973	37	54	0	2	3	0	3	59
1974	37	32	16	0	10	0	5	19
1975	35	30	0	0	20	9	6	54
1976	35	33	2	0	20	4	6	125
1977	31	45	0	0	14	4	6	181
1978	5	53	2	0.2	24	0	16	490
1979	10	51	10	0	11	3	14	172[a]
Total (no.)	191	522	33	2	201	22	128	1,100
Percentage	17.4	47.5	3.0	0.2	18.3	2.0	11.6	

[a] Includes one isolate of race 13.

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Race 4 was isolated more frequently during the last 2 yr of the survey, following the release of cultivars Vickery in 1978 and Wells II in 1979; both cultivars have the gene Rps_1^c and are susceptible only to races 4, 5, 12, 14, and 16. However, race 5 was not isolated more frequently in these years, despite this apparent selection pressure. Two other cultivars with the gene Rps_1^c, Williams 79 and Beeson 80, have been released to certified seed producers, so any selection pressure they may exert on races 4 and 5 should become evident in the near future.

Races 2 and 6 have not been found in Indiana. Many commercial cultivars are resistant to race 2, but a selection pressure for race 2 would not result, because none of them are exclusively susceptible to race 2. There is no obvious explanation for the absence of race 6; apparently, like race 5, it is not as competitive as the other races.

The new physiologic races of the pathogen (other than race 1) were found in 22 counties in central and northern Indiana (Fig. 1), where the soils are most conducive to the development of the disease, and where the disease has been most severe. The new races have not been found in Tipton County or seven adjacent counties to the south—Fountain, Montgomery, Boone, Marion, Hancock, Henry, and Wayne—even though race 1 is prevalent in this area on susceptible cultivars. The disease is not prevalent in Carroll and Cass counties or counties to the north, presumably because the soils are lighter and better drained. Testing more isolates from either of these regions might reveal the presence of some new races.

Table 2 lists the new physiologic races that have been found, by county and year. Races 3, 5, 7, and 9 were first found in 1973, and races 3, 7, and 9, the three most prevalent new races, have been found every year since then. Race 5 was found again only in 1978. Race 4 was first found in 1974 but was not isolated in 1975 and 1977. Race 8 was not found in Indiana until 1975 but has been found every year since then except 1978.

Apparently only race 1 was present until 1973 because cultivars with the Rps_1 gene, which controls resistance to races 1 and 2, were free of the disease before then. The data suggest that the new races all arose at about the same time. Selection pressure for races virulent to cultivars with gene Rps_1 probably was responsible for the appearance of these races but does not account for the occurrence of more than one new race. Now that several cultivars resistant to races 1–3 and 6–9 are available, the disease may diminish or races 4 and 5 may become more prevalent. So far, we have not been able to determine if the prevalence of either or both races has changed. We have made a special effort to isolate the pathogen from cultivars with gene Rps_1^c and have found only race 4. Because race 5 has not been isolated from these cultivars and because it was found in only two of 1,100 isolates in 7 yr (Table 1), race 5 appears to be less competitive or aggressive than some of the other races.

We will soon release commercial cultivars with the genotypes $Rps_1^b Rps_3$ or $Rps_1^c Rps_3$ that are susceptible only to race 12. Then, either race 12 or additional new races virulent to these genotypes will develop or the pathogen will cease to exist on these cultivars.

Table 2. New physiologic races of *Phytophthora megasperma* f. sp. *glycinea* found in Indiana, by county and year, 1973–1979

Race[a]	Counties (years)
3	Adams (73–79), Allen (73–79), Benton (79), Clinton (79), Grant (77–79), Hamilton (78,79), Howard (78,79), Huntington (78), Jasper (76,77,79), Jay (73,77,78), Miami (76), Newton (76), Randolph (76–78), Tippecanoe (78,79), Wabash (75), Warren (79), Wells (76–79), White (74,77–79)
4	Adams (76,78), Allen (79), Blackford (75,76), Huntington (78), Jasper (79), Jay (74), Wells (78), White (78,79)
5	Allen (73,78)
7	Adams (75,76,78), Allen (73,75–79), Blackford (76), Howard (78,79), Huntington (78), Jasper (77), Lake (78), Randolph (76), Wells (74–79), White (77–79)
8	Adams (76,77), Allen (75,77,79), Howard (75), Huntington (75), Jay (76,77,79), Randolph (79)
9	Adams (75–79), Allen (74,76–79), Blackford (78), Delaware (73), Grant (78), Huntington (78), Jay (76–79), Madison (78), Tippecanoe (78), Wells (75,77–79), White (78,79)
13	Allen (78)

[a] Data for race 1 (45 counties, 1973–1979) not shown.

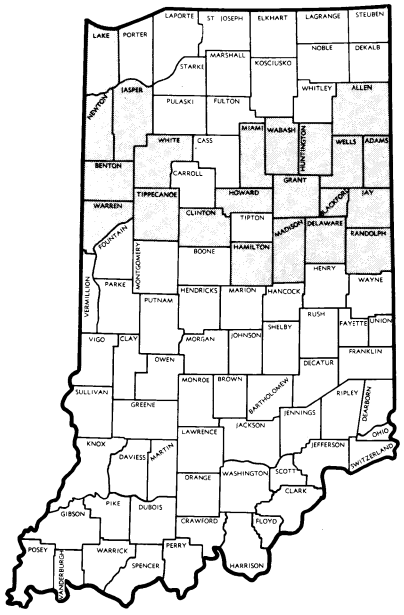

Fig. 1. Area of Indiana where new physiologic races of *Phytophthora megasperma* f. sp. *glycinea* were found.

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