Epidemiology of Phomopsis Seed Decay of Soybean in Illinois

B. J. SHORTT, Graduate Research Fellow, A. P. GRYBAUSKAS and F. D. TENNE, Former Graduate Research Assistants, and J. B. SINCLAIR, Professor, Department of Plant Pathology, University of Illinois, Urbana 61801

ABSTRACT

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In a 3-yr study of seed decay of soybean (*Glycine max*) caused by *Phomopsis* spp. in Illinois, disease incidence was highest in 1977, lowest in 1976, and intermediate in 1975. A low positive correlation was found between temperature and disease incidence, but no consistent continuum of disease from north to south within the state was apparent. The highest incidence of Phomopsis seed decay occurred along major waterways in the wet years of 1975 and 1977. A high positive correlation was found between disease incidence and rainfall during pod fill, indicating that moisture, rather than temperature or geographic area, is the dominant environmental factor in disease development. Maturity dates of cultivars interacted with changing weather conditions to affect disease incidence. In our studies, cultivars in maturity group II had the highest level of Phomopsis seed decay. Cultivars used in seed production in Illinois should be grown at latitudes where they will mature late in the season and escape conditions conducive to high incidence of seed decay.

Phomopsis seed decay of soybean (*Glycine max* (L.) Merr.) is part of a disease complex caused by species of *Diaporthe* and their *Phomopsis* anamorphs (5). The disease is endemic in Illinois and causes reduced germination, vigor, yield, and quality of soybean and other large-seeded legume seeds (3,7,8). High moisture and temperature have been reported to increase disease severity. Lehman (7) observed that high humidity and warm temperatures were conducive to seed infection by *Phomopsis* spp., and Kmetz et al (6) and Hepperly and Sinclair (4) demonstrated that *Phomopsis* conidia are disseminated by splashing rain. High levels of seed infection also have been associated with delayed harvest (10).

The Illinois Crop Improvement Association (ICIA), Urbana, has monitored the incidence of Phomopsis seed decay in certified soybean seedlots grown in Illinois for several years. Though previously observed, the relationships among rainfall, temperature, and disease severity have not been quantified, and the relationship between geography and disease incidence is poorly understood. We report on the effects of rainfall, temperature, location, and maturity group on the occurrence of Phomopsis seed decay of certified soybean seeds grown throughout Illinois in 1975–1977.

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MATERIALS AND METHODS

Illinois-grown soybean seedlots harvested in 1975–1977 and eligible for certification by the ICIA were assayed for seed quality. Four 100-seed samples from each seedlot were placed on a moist 48-cm square cellulose pad (Kimpac, Graham Paper Co., St. Louis, MO) and incubated under continuous fluorescent light at 95% relative humidity and 22 C.

After 7 days, the percentages of germination, vigorous seedlings, and Phomopsis seed decay were recorded. A seed was considered germinated if the radical was 2.5 cm or longer. A seedling was considered vigorous if during germination the cotyledons were lifted 1 cm or more from the surface of the cellulose pad.

Because more than 8,000 seedlots were assayed, microscopic identification of each *Phomopsis*-decayed seed was impossible. Seeds decayed and killed by *Phomopsis* spp. were recognized by a characteristic thick, white coating of mycelium with or without typical *Phomopsis* pycnidia. *Phomopsis* is by far the predominant cause of soybean seed decay in Illinois and can be distinguished from other seed inhabitants by the color, texture, and growth habits of the mycelial mat. Other pathogens of soybean seeds were infrequently observed. Therefore, we believe that the experimental error from basing our identifications on gross fungal morphology is very low.

The data were collected from 2,708, 2,713, and 2,699 seedlots harvested in 1975, 1976, and 1977, respectively, and were analyzed with the Statistical Analysis System prepackaged computer programs (2) at the University of Illinois, Urbana. The Environmental Data Service of the National Oceanic and Atmospheric Administration, U.S. Department of Commerce, supplied rainfall and temperature records from stations throughout Illinois.

RESULTS

The assay using cellulose pads efficiently detects Phomopsis seed decay—ie, those seeds killed by *Phomopsis* spp. before or during germination—but does not detect *Phomopsis* infections in viable seeds. Thus, the disease levels detected in this study generally underestimate the total incidence of *Phomopsis* spp.

Seed quality. Quality of the seedlots as measured by germination, vigorous seedlings, and decayed seeds varied among years (Table 1). Seedlots produced in 1975 and 1976 had moderate and low disease incidence, respectively, with levels

Table 1. Percentages of germination, vigorous seedlings, and Phomopsis seed decay among soybean seedlots grown in Illinois

	Year[a]			
Measure of seedlot quality	**1975**	**1976**	**1977**	**FLSD[b]**
Germination	96.0	86.8	81.3	0.35
Vigorous seedlings	79.2	80.9	73.4	0.45
Seed decay	5.5	0.8	10.3	0.35

[a] Based on four replicates of 100 seeds from each of 2,708, 2,713, and 2,699 seedlots produced in 1975, 1976, and 1977, respectively.

[b] Fisher's least significant difference ($P = 0.05$).

of germination and seedling vigor suitable for crop production. However, seedlots produced in 1977 had a higher incidence of Phomopsis seed decay concomitant with lower germination and seedling vigor. Because of the low quality of these seedlots, shortages of certified seeds of some cultivars occurred, and fungicide seed treatments and high planting rates were often used (G. W. Keith, Manager, ICIA, *personal communication*).

Phomopsis seed decay was highly correlated with both germination (−0.860) and seedling vigor (−0.834) for the 3 yr of this study. The correlation coefficients between disease incidence and germination in 1975, 1976, and 1977 were −0.848, −0.378, and −0.954, respectively. The low coefficient for 1976 is a result of dry conditions during crop maturation, which limited infection by *Phomopsis* spp. and contributed to increased mechanical damage to seeds during combining.

Regional disease levels. The mean disease incidence in seedlots from each Illinois county was calculated, and disease distribution maps were constructed for each year (Fig. 1). Disease incidence among seedlots produced in 1975 ranged from 0 to 50%; however, mean disease levels for each county were classified primarily in the low (0–5%) and intermediate (5–10%) ranges. Counties with similar disease levels were not randomly scattered but formed homogeneous groups. The majority of counties with levels in the low range were found in the northern and southwest-central areas of the state. Seedlots produced in central and southern Illinois were classified in the intermediate range for seed decay. All three counties with disease levels in the high range (10–15%) were located in southern Illinois bordering the Mississippi or Ohio rivers.

Seedlots produced in 1976 had low levels of Phomopsis seed decay, ranging from 0 to 24%. Mean disease incidences by county were all in the low range, and no differences were found among regions.

Disease incidence increased in 1977 and ranged from 0 to 95%. Counties with mean disease levels of 5–10% formed a homogeneous grouping in east and southwest-central Illinois. Thirteen counties had mean disease levels in the high range, and nine were in the very high (more than 15%) range. These counties were either scattered or grouped but were all transected or bordered by a major river. Disease incidence was highest in counties along the Illinois River in north central Illinois.

Environmental factors. To aid in data analysis, the state was divided into nine U.S. Department of Agriculture crop reporting districts of approximately equal size: northwest, northeast, west, central, east, west-southwest, east-southeast, southwest, and southeast. Mean disease incidence, total rainfall, and mean temperatures during August, September, and October were determined for each district and year.

Multiple regression analysis indicated that total rainfall during the 3 mo was the determining factor ($r^2 = 0.75$) in the variability of the incidence of Phomopsis seed decay (Fig. 2). The correlation between disease incidence and mean temperature during the same period was low ($r = 0.35$) but significant ($P = 0.05$). However, adding this variable to the model resulted in an insignificant increase (0.02) in the r^2 value (0.77). Total rainfall varied widely, but mean temperatures did not and were within the range acceptable for growth of *Phomopsis* spp.

Variability among cultivars. No cultivar had consistently less Phomopsis seed decay when compared with all other cultivars grown in different regions and years. Significant interactions occurred between counties and cultivars in the overall analysis, but because of the large numbers of each (77 and 44, respectively), no general tendencies were detected.

Variation among maturity groups, however, was much more consistent. Most soybeans grown in Illinois belong to maturity groups II, III, or IV and reach harvest maturity in late August, mid-September, and early October, respectively. Production of cultivars in groups I and V is limited in Illinois. The incidence of Phomopsis seed decay differed among

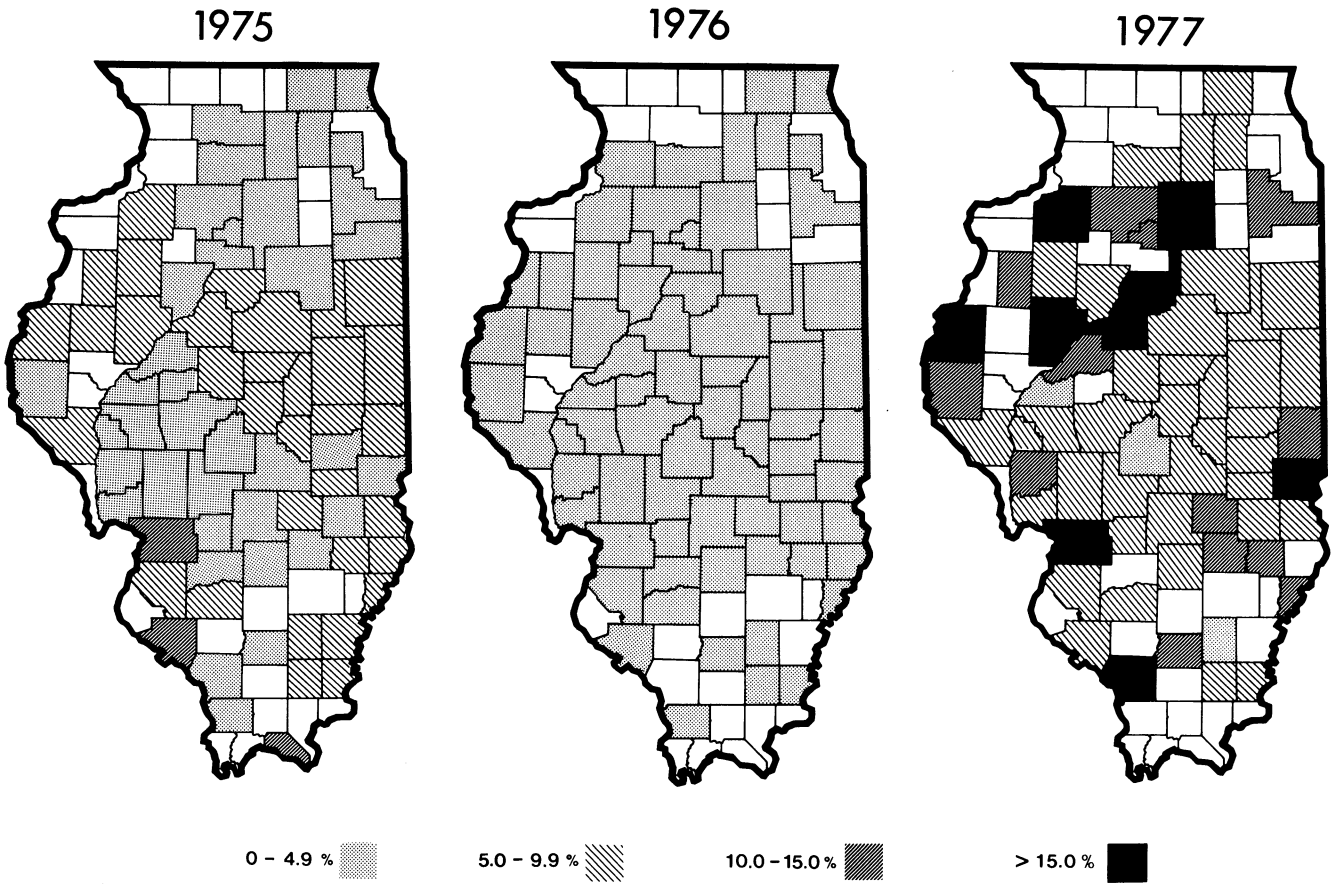

Fig. 1. Mean incidence of Phomopsis seed decay in Illinois, by county and year.

Table 2. Occurrence of Phomopsis seed decay by maturity group and year in soybean seedlots grown in Illinois

Maturity group	Number of seedlots	Phomopsis seed decay (%)[y]			
		1975	1976	1977	Mean
I	63	5.45 ab[z]	0.45 b	7.40 bc	4.02 bc
II	2,735	6.24 a	0.92 b	12.61 a	6.37 a
III	3,929	5.23 b	0.72 b	9.46 b	5.14 b
IV	1,249	5.00 b	1.11 a	9.60 b	5.37 b
V	134	2.94 b	1.06 ab	3.27 c	2.76 c

[y] Based on four replicates of 100 seeds each per seedlot.
[z] Numbers in column with a letter in common are not significantly different based on the new Duncan's multiple range test ($P = 0.05$).

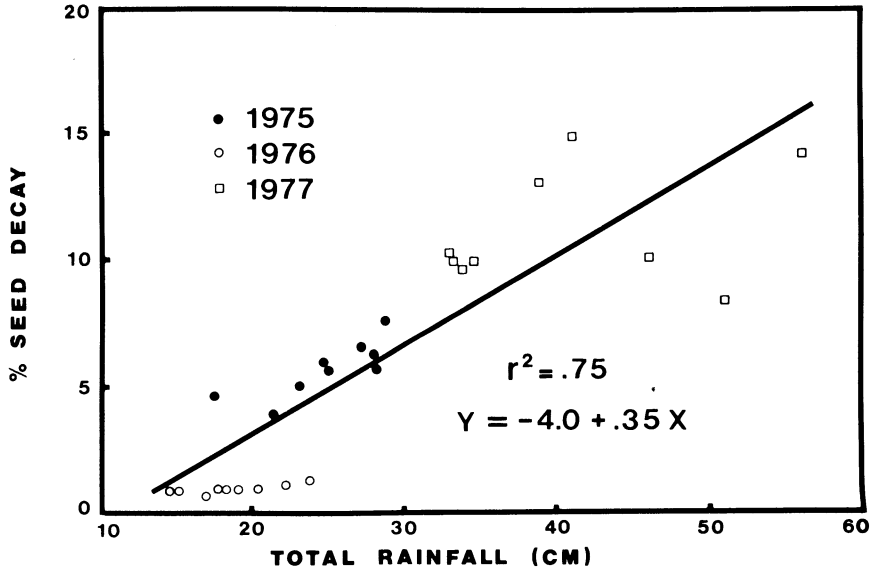

Fig. 2. Relationship between total rainfall during August, September, and October and percentage of Phomopsis seed decay in Illinois. Each point represents one district and year.

maturity groups in 1975 and 1977, when disease levels were high (Table 2). The mean disease incidence for cultivars in maturity group II was significantly higher than that for the other groups. The lowest incidence of Phomopsis seed decay occurred among cultivars in group V; no differences occurred between groups III and IV. The differences among maturity groups increased as disease incidence increased.

DISCUSSION

Phomopsis seed decay of soybean is endemic in Illinois but varies in incidence among years, cultivars, and regions of the state. We found that the highest levels of disease occurred in wet years in counties bordering major waterways and that timing and amount of rainfall affected disease incidence. Production of conidia increases and most pod and seed infections occur during pod filling and crop maturation (1,6,8). Our data showed that the amount of rainfall during late pod filling and crop maturity (August, September, and October in Illinois) was related to the incidence of Phomopsis seed decay. The high positive correlation between rainfall and disease incidence supports the observations of Lehman (7) and Wilcox et al (10).

Seed quality has been reported to decrease from north to south in Illinois (9), which suggests that temperatures during maturation may affect disease incidence. Our data indicate that although mean temperatures during August, September, and October do increase from north to south, higher disease incidence does not necessarily follow. The differences among mean temperatures were small and probably had little effect on disease incidence. Timing of the maturation period varies among cultivars. The different maturity dates for cultivars grown at different latitudes in the state may partially account for the lack of a disease gradient from north to south.

Our results indicate that the distribution of Phomopsis seed decay was primarily influenced by and reflects the rainfall patterns during the maturation period of the crop. Cultivars in maturity group II had higher levels of Phomopsis seed decay than those in groups I, III, IV, and V. Cultivars in group II mature in late August or early September in Illinois and generally are exposed to high rainfall and warm temperatures common at that time of year. Group I cultivars mature earlier and are more often exposed to hotter, drier conditions during pod filling. Conversely, cultivars in groups III and IV mature later in September and in early October, when conditions again are less favorable for disease development. We believe that Phomopsis seed decay can be partially controlled by growing cultivars at latitudes where they will mature late in the season and thereby escape environmental conditions most conducive to high disease incidence.

ACKNOWLEDGMENTS

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