Factors Affecting Soybean Seed Quality in Illinois

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ABSTRACT

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Soybean seeds harvested from 18 northern and 12 southern Illinois soybean disease-monitoring plots were assayed for quality from 1978 to 1981. Weather and soil conditions in northern plots were more conducive to plant growth and high-quality seed production than those in southern plots. Seed weight and percent radicle emergence were greatest from northern plots, whereas numbers of fungus-infected and noninfected-nonviable seeds were greatest from southern plots. Numbers of seeds infected by *Aspergillus* spp., *Chaetomium* spp., and *Phomopsis* spp. were highest in northern plots, whereas numbers of seeds infected by *Alternaria* spp., *Cercospora kikuchii, Cladosporium* spp., *Colletotrichum* spp., *Fusarium* spp., *Macrophomina phaseolina, Nematospora coryli, Penicillium* spp., and *Phoma* spp. were highest in southern plots.

Soybean seed quality refers to a range of characteristics that affect marketability and includes test weight, germination, vigor, and numbers of damaged, discolored, mottled, or moldy seeds (1). Previous investigations (2,3,8) related variations in Illinois soybean seed quality to the region (north, central, or south) in which the seeds were grown. Soybean seeds grown in central and northern Illinois had high rates of germination and low incidence of fungal seed decay in 1963, 1964, and 1972 through 1975, whereas seeds grown in southern Illinois had low rates of germination and high levels of infection by *Phomopsis* spp. and other fungi (2,3,8). In 1972, poor-quality soybean seeds were associated with high percentages of Phomopsis seed decay and with above-normal rainfall during harvest (2). Further research (5) demonstrated that precipitation from maturation to harvest during the 1975–1977 growing seasons was the most important factor affecting the incidence of Phomopsis seed decay. Our study relates differences in soybean growth and seed quality in northern and southern Illinois to differences in soil and weather conditions.

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MATERIALS AND METHODS

Seeds were harvested from soybean disease-monitoring plots at 11, 9, 9, and 1 location in Illinois in 1978, 1979, 1980, and 1981, respectively. The locations of plots in northern Illinois (and years included in the survey) were Dekalb (1978–1980), Hartsburg (1978–1980), Macomb (1978–1980), Manlius (1978), Saunemin (1978), Standard (1979–1980), and Urbana (1978–1981). Locations and years in southern Illinois were Belleville (1978–1980), Brownstown (1978–1980), Carbondale (1978–1980), Dixon Springs (1979–1980), and Eldorado (1978). In 1978, data were recorded from two soybean disease-monitoring plots at the University of Illinois research fields in Urbana (Fig. 1).

Soybeans in northern Illinois were grown in Mollisol soils with medium to high organic matter content (3.5–6.0%, av. 4.8%), good drought resistance, and high natural fertility. Of the 12 plots in southern Illinois, eight were planted in Alfisol soils and two in Entisol soils. Both Alfisols and Entisols have low to medium organic matter content and low natural fertility. The organic matter of the Alfisols and Entisols in this study ranged from 1.5 to 2.0% with an average of 1.8%. The remaining two plots were planted in Mollisols with medium organic matter contents of 3.5 and 4.0% and properties similar to Mollisols at the northern locations.

At each location, three replicates of 16 cultivars were grown in three-row plots arranged in a randomized complete block design. Unit rows were 76.2 cm (30 in.) wide and 6.7 m (22 ft) long. The cultivars by maturity group were Amsoy, Amsoy 71, Beeson, Corsoy, and Wells from group II; Elf, L-22, Williams, and Woodworth from group III; Clark, Clark 63, Cutler 71, Franklin, Kent, and Union from group IV; and Essex from group V. At maturity, plants from the middle row of each plot were harvested. Seeds were threshed with a Swanson plot thresher (Swanson Machine Co., Champaign, IL) and placed in cloth bags. Each sample was passed through a seed cleaner and stored at 5 C and 12–15% relative humidity. Three hundred seeds from each replicate were weighed and placed in a small cloth bag. Seeds were surface-disinfested in a sodium hypochlorite (0.5% available chlorine) solution for 4 min, then rinsed twice in distilled water for 1 min. The excess water was allowed to drain off, and the seeds were placed in a sterile plastic culture plate. One hundred seeds were chosen at random and placed in 20 culture plates of potato-dextrose agar (Difco) with five seeds per plate. After 10 days in continuous darkness at 25 C, percent radicle emergence was recorded and fungi associated with the seeds were identified.

The following mean values for northern and southern plots were determined: percent radicle emergence, seed weight, percent fungus-infected seeds, percent noninfected-nonviable seeds, and percent seeds infected by each of 12 genera of fungi. Data were subjected to

Fig. 1. Locations of Illinois soybean disease-monitoring plots during 1978–1981.

analysis of variance and means compared using Duncan's multiple range test.

The average precipitation and average number of growing degree days (heating units) from planting to harvest for northern and southern monitoring locations also were compared. Growing degree days were used as a measure of the hotness or coldness of a growing region of the state. A growing degree day is one Fahrenheit degree of temperature above a threshold temperature (50 F for soybeans) at which growth begins. Daily growing degree days were calculated by subtracting 50 from the average of the maximum and minimum temperatures for the day.

RESULTS

The overall average weight and percent radicle emergence (viability) were significantly greater ($P = 0.05$) for seeds grown in 18 northern plots than for seeds grown in 12 southern plots, where the numbers of fungus-infected and non-infected-nonviable seeds were significantly higher (Table 1). More growing degree days occurred in southern plots than in northern plots. Overall, rainfall was greater in northern plots than in southern plots, although yearly differences were not consistent. In 1979, average rainfall was less in five northern plots than in four southern plots (Table 1).

In 1981, data were recorded from one plot at Urbana, where temperatures were moderate and rainfall was slightly above normal throughout the growing season. Seed weight and percent radicle emergence were high, whereas numbers of fungus-infected seeds and of noninfected-nonviable seeds were low (Table 1).

The occurrence of fungi most commonly isolated from soybean seed differed between the two regions (Table 2). The numbers of seeds infected by *Alternaria* spp., *Cercospora kikuchii* (T. Matsu. & Tomoyssu) Gardner, *Cladosporium* spp., *Colletotrichum* spp., *Fusarium* spp., *Macrophomina phaseolina* (Tassi) Goid., *Nematospora coryli* Pegli, *Penicillium* spp., and *Phoma* spp. that were harvested from the 12 southern plots were significantly greater ($P = 0.05$) than those from the 18 northern plots. Of these fungi, yearly differences between northern and southern plots were inconsistent only for seed infection by *Alternaria* spp. In 1979, the number of seeds infected by *Alternaria* spp. was greater in northern plots than in southern plots. Compared with seeds harvested from southern plots, more seeds from northern plots were infected by *Aspergillus* spp., *Chaetomium* spp., and *Phomopsis* spp. Yearly differences between northern and southern plots were inconsistent for both *Aspergillus* spp. and *Chaetomium* spp.

The fungi most commonly isolated from seed from the 30 field plots and their mean percent recovery were *Phomopsis* spp. (11.52), *Alternaria* spp. (4.40), *C. kikuchii* (4.38), and *Cladosporium* spp. (2.59). The mean percent recovery of other fungi was less than 1% and included *Aspergillus* spp. (0.65), *Chaetomium* spp. (0.68), *Colletotrichum* spp. (0.15), *Fusarium* spp. (0.76), *M. phaseolina* (0.88), *N. coryli* (0.28), *Penicillium* spp. (0.49), and *Phoma* spp. (0.05).

DISCUSSION

Weather and soil conditions in northern Illinois were more conducive to plant growth and high-quality soybean seed production than the often stressful environmental conditions in southern Illinois. Conditions in northern Illinois favored a good supply of soil moisture to roots and thus promoted plant growth. In the north, rainfall was adequate and evenly distributed over locations and occurred at regular intervals.

In contrast, conditions in southern Illinois often limited the amount of soil moisture available to roots, adversely affecting plant growth and resulting in poor soybean stands with low-quality seeds. Soybean stands were frequently under drought stress for weeks or months. Inadequate rainfall and poor soil conditions were the main contributing factors.

Differences in the prevalence of seedborne fungi between nothern and southern Illinois were apparently associated with differences in environmental conditions. The hotter growing seasons in the south were more favorable for seed infection by *C. kikuchii*, *Colletotrichum* spp., *M. phaseolina*, and *N. coryli*. Furthermore, high levels of seed infection by *C. kikuchii* and *Colletotrichum* spp. were associated with the highest rainfall in the south (39.3 cm in 1979), whereas a high level of seed infection by *M. phaseolina* was associated with the lowest rainfall (27.4 cm in 1978). These results agree with previous findings (7) indicating that pathogenicity of *C. kikuchii* and *Colletotrichum* spp. is favored by hot, wet weather, whereas pathogenicity of *M. phaseolina* is favored by hot, dry weather. Seed infection by *N. coryli* is common in the southern United States, where growing seasons hotter than in Illinois are favorable for growth of *N. coryli* (7). In our study, a high level of seed infection by *N. coryli* was associated with the hottest growing season in the south (3,431 growing degree days in 1980) and was rarely observed otherwise. The observed increase in *N. coryli* with increasing temperature may be related to the increased activity of its vector, the stinkbug. Similarly, seed infection by *Phoma* spp. was greatest in southern Illinois in 1980.

Numbers of seeds infected by *Cladosporium* spp., *Fusarium* spp., and *Penicillium* spp. also were higher in southern Illinois, where stressful environmental conditions predisposed pods and seeds to penetration and colonization by these fungi. In addition, the overall mean for seed infection by *Alternaria* spp. was greatest in southern Illinois. Yearly differences indicate, however, that seed infection by *Alternaria* spp. was more

Table 1. Seed-quality and weather information for Illinois soybean disease-monitoring plots

Region	1978[s]	1979[t]	1980[u]	1981[v]	Mean[w]
			Seed weight (g/300 seed)		
Northern	51.0 a[x]	50.1 a	47.1 a	48.4	49.5 a
Southern	42.2 b	49.8 a	40.2 b	NP	44.1 b
			Radicle emergence[y] (%)		
Northern	87.5 a	84.2 a	91.4 a	94.4	88.1 a
Southern	77.8 b	77.6 b	82.1 b	NP	79.2 b
			Fungus-infected seed[y] (%)		
Northern	30.3 b	20.5 b	18.4 a	13.9	23.4 b
Southern	42.6 a	33.0 a	20.3 a	NP	32.0 a
			Noninfected-nonviable seed[y] (%)		
Northern	1.8 b	3.4 b	1.9 b	0.9	2.2 b
Southern	3.8 a	4.4 a	5.3 a	NP	4.5 a
			Growing degree days[z]		
Northern	2,754.5 b	2,682.8 b	3,010.5 b	2,558.6	2,794.8 b
Southern	2,875.0 a	2,736.6 a	3,431.0 a	NP	3,014.2 a
			Rainfall[z] (cm)		
Northern	39.4 a	36.3 b	58.0 a	61.0	44.9 a
Southern	27.4 b	39.3 a	35.7 b	NP	34.1 b

[s] In 1978, data from seven northern plots were compared with data from four northern plots.
[t] In 1979, data from five northern plots were compared with data from four southern plots.
[u] In 1980, data from five northern plots were compared with data from four southern plots.
[v] For 1981, data from one northern plot are presented; NP = no plots were planted in the southern region.
[w] Means represent average values for 18 northern plots (1978–1981) and 12 southern plots (1978–1980).
[x] For each seed-quality and weather category, numbers in columns followed by the same letter are not significantly different ($P = 0.05$) according to Duncan's multiple range test.
[y] Based on ratings of 4,800 seeds (three replicates of 100 seeds of 16 cultivars) per plot.
[z] Based on daily records of temperature and precipitation compiled from planting to harvest.

closely associated with lowest rainfall in northern or southern regions than with the hotter growing seasons in the southern region. Previous reports have related seed infection by *Alternaria* spp. to other stress conditions such as insect injury (4,6), frost injury (9), and delayed harvest (10).

Table 2. Incidence of fungi on surface-disinfested seed from Illinois soybean disease-monitoring plots

Region	Percent infected seed[t]				
	1978[u]	1979[v]	1980[w]	1981[x]	Mean[y]
		Aspergillus spp.			
Northern	2.13 a[z]	0.15 b	0.03 a	1.67	0.97 a
Southern	0.10 b	0.34 a	0.07 a	NP	0.17 b
		Alternaria spp.			
Northern	4.15 b	4.35 a	3.32 b	0.54	3.77 b
Southern	10.04 a	1.69 b	4.27 a	NP	5.33 a
		Cercospora kikuchii			
Northern	1.11 b	0.82 b	3.78 b	0.52	1.74 b
Southern	7.17 a	12.20 a	5.58 a	NP	8.32 a
		Cladosporium spp.			
Northern	1.75 b	2.98 a	0.76 b	3.12	1.89 b
Southern	5.45 a	3.23 a	2.22 a	NP	3.63 a
		Colletotrichum spp.			
Northern	0.08 a	0.03 b	0.01 a	0.15	0.05 b
Southern	0.05 a	0.81 a	0.02 a	NP	0.29 a
		Chaetomium spp.			
Northern	2.17 a	0.09 a	0.02 b	0.15	0.88 a
Southern	0.95 b	0.10 a	0.13 a	NP	0.39 b
		Fusarium spp.			
Northern	0.77 b	0.12 b	0.16 b	0.15	0.39 b
Southern	1.94 a	0.92 a	1.07 a	NP	1.31 a
		Macrophomina phaseolina			
Northern	0.20 b	0.01 b	0.04 b	0.00	0.09 b
Southern	5.80 a	0.16 a	0.21 a	NP	2.06 a
		Nematospora coryli			
Northern	0.00	0.01 a	0.00 b	0.00	0.00 b
Southern	0.00	0.00 a	2.03 a	NP	0.68 a
		Penicillium spp.			
Northern	0.61 a	0.30 b	0.12 b	0.85	0.40 b
Southern	0.69 a	0.72 a	0.47 a	NP	0.63 a
		Phoma spp.			
Northern	0.00	0.02 a	0.04 b	0.00	0.02 b
Southern	0.00	0.01 a	0.29 a	NP	0.10 a
		Phomopis spp.			
Northern	17.34 a	11.65 a	10.14 a	6.65	13.15 a
Southern	10.45 b	12.86 a	3.96 b	NP	9.09 b

[t] Based on ratings of 4,800 seeds (three replicates of 100 seeds of 16 cultivars) per plot.
[u] In 1978, data from seven northern plots were compared with data from four southern plots.
[v] In 1979, data from five northern plots were compared with data from four southern plots.
[w] In 1980, data from five northern plots were compared with data from four southern plots.
[x] For 1981, data from one northern plot are presented; NP = no plots were planted in the southern region.
[y] Means represent average values for 18 northern plots (1978–1981) and 12 southern plots (1979–1980).
[z] For each fungal genus, numbers in columns followed by the same letter are not significantly different ($P = 0.05$) according to Duncan's multiple range test.

Although the overall means for seed infection by *Aspergillus* spp., *Chaetomium* spp., and *Phomopsis* spp. were greater in the north than in the south, the highest means within individual years varied between regions. The high levels of seed infection by *Aspergillus* spp. in the north in 1978 and in the south in 1979 were associated with high rainfall, which agrees with reports of other investigators (2,9). High levels of seed infection by *Phomopsis* spp. were associated with high rainfall, which also agrees with previous reports (2,5). Seed infection by *Chaetomium* spp. varied greatly, and further studies are needed to determine the factors favorable for seed infection by this fungus.

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LITERATURE CITED

1. Caviness, C. E. 1978. Environmental effects on soybean seed quality. Pages 79-85 in: Am. Seed Trade Assoc. Publ. 8. H. D. Loden and D. Wilkinson, eds. Washington, DC.
2. Chamberlain, D. W., and Gray, L. E. 1974. Germination, seed treatment, and microorganisms in soybean seed produced in Illinois. Plant Dis. Rep. 58:50-54.
3. Foor, S. R., Tenne, F. D., and Sinclair, J. B. 1976. Occurrence of seedborne microorganisms and germination in culture for determining seed health in soybeans. Plant Dis. Rep. 60:970-973.
4. Kilpatrick, R. A., and Hartig, E. E. 1955. Fungus infection of soybean seed as influenced by stink bug injury. Plant Dis. Rep. 39:177-180.
5. Shortt, B. J., Grybauskas, A. P., Tenne, F. D., and Sinclair, J. B. 1981. Epidemiology of Phomopsis seed decay of soybean in Illinois. Plant Dis. 65:62-64.
6. Shortt, B. J., Sinclair, J. B., Helm, C. G., Jeffords, M. R., and Kogan, M. 1982. Soybean seed quality losses associated with bean leaf beetles and *Alternaria tenuissma*. Phytopathology 72:615-618.
7. Sinclair, J. B., ed. 1982. Compendium of Soybean Diseases. 2nd ed. American Phytopathological Society, St. Paul, MN. 104 pp.
8. Tenne, F. D., Prasartsee, C., Machado, C. C., and Sinclair, J. B. 1974. Variation in germination and seedborne pathogens among soybean seed lots from three regions in Illinois. Plant Dis. Rep. 58:411-413.
9. Tervet, I. W. 1945. The influence of fungi on storage, on seed viability, and seedling vigor of soybeans. Phytopathology 35:3-15.
10. Wilcox, J. R., Laviolette, F. A., and Athow, K. L. 1974. Deterioration of soybean seed quality associated with delayed harvest. Plant Dis. Rep. 58:130-133.