Quality Losses in Phomopsis-Infected Soybean Seeds

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ABSTRACT


Several measurements of seed quality were used to compare symptomatic seeds were associated with premature death and soybean (Glycine max 'Wells') seeds with and without the breakdown of seedcoat tissues. Thiram seed treatment symptoms or signs of Phomopsis sojae infection. Seeds with symptoms contained more oil, protein, and recoverable P. sojae than symptomless seed. In addition, symptomatic seeds were smaller in size and volume, were lower in density, produced lower quality oil and flour, and had lower viability and durability than did symptomless seeds. Quality losses in symptoms contained more oil, protein, and recoverable P. sojae than symptomless seed. In addition, symptomatic seeds were smaller in size and volume, were lower in density, produced lower quality oil and flour, and had lower viability and durability than did symptomless seeds. Quality losses in

Additional key words: Pod and stem blight.

Prior to 1960 Phomopsis sojae Leh., causal agent of pod and stem blight of soybean (Glycine max [L.] Merr.), was considered of little importance to soybean production (1,13,19,22). Since that time, significant germination losses have been reported in heavily infected seedlots in the United States and Canada (9,10,27). Presently, P. sojae is recognized as a major cause of moldy, poorly germinating soybean seeds in Brazil, Canada, and the United States (4,5,7,27). Phomopsis seed infection often exceeds 50% on susceptible cultivars when harvest is delayed (9,23,28). Increasing concern over the quality of soybean seed has resulted in the printing of "percent Phomopsis-moldy seed" on soybean certification tags by the Illinois Crop Improvement Association, Urbana. Much is known about the ability of this pathogen to reduce seed viability and vigor, yet little is known about how P. sojae influences other seed quality factors. We report on the effect of infection by P. sojae on soybean grade components and composition as well as on the quality of soybean flour and oil.

MATERIALS AND METHODS

A seed lot of Wells soybeans was harvested in mid-October 1975 at 12% moisture from the University of Illinois Agronomy South Farm, Urbana, and stored at 0-2 C until used. The seed lot averaged over 50% infection with P. sojae, with many seeds showing discoloration, fissuring, flattening, and the presence of greyish-white fungal mycelium. The seed lot was divided into sublots of seeds with and without these symptoms.

To measure the effect of P. sojae on soybean seed quality, the following tests were conducted on four or more 100-seed samples for each seed type: germination losses have been reported in heavily infected seedlots in the United States and Canada (9,10,27). Presently, P. sojae is recognized as a major cause of moldy, poorly germinating soybean seeds in Brazil, Canada, and the United States (4,5,7,27). Phomopsis seed infection often exceeds 50% on susceptible cultivars when harvest is delayed (9,23,28). Increasing concern over the quality of soybean seed has resulted in the printing of "percent Phomopsis-moldy seed" on soybean certification tags by the Illinois Crop Improvement Association, Urbana. Much is known about the ability of this pathogen to reduce seed viability and vigor, yet little is known about how P. sojae influences other seed quality factors. We report on the effect of infection by P. sojae on soybean grade components and composition as well as on the quality of soybean flour and oil.

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Protein and oil content were determined using the Dickey-John Infrared Analyzer (14). Before analysis, flours were adjusted to 6% moisture. Five determinations were made for each of four 100-seed samples.

To test susceptibility of grain to splitting, five 100-seed samples of nonsplit seed from each seed type were placed in cloth bags and tumbled for 1 hr in a soil mixture to simulate grain handling. The number of split seeds was recorded after treatment.

Flour and oil quality were tested by preparing flours from each seed type by grinding them in a Waring Blender or for 1 min. Prepared flours were organoleptically rated for “off” odor by 15 panelists in a blind study using the following ratings: (i) imperceptible, (ii) slightly perceptible, (iii) moderately perceptible, (iv) perceptible, (v) slightly pronounced, (vi) moderately pronounced, and (vii) very pronounced. Flour samples then were transferred to extraction thimbles and placed into Soxhlet extractors. Oil was extracted at 65°C with petroleum ether for 4 hr. The solvent was removed under vacuum overnight at 50°C. Four oil samples from each seed type were analyzed for peroxides using the standard American Oil Chemists’ Society method for soybean (20). Oil from P. sojae-symptomatic seeds was visibly darker when compared with that from symptomless seed (Table 2).

RESULTS AND DISCUSSION

With the exception of yield, grade is the major determinant of producer profit. Reductions in grade can cause sizable economic losses for growers. Seedborne P. sojae has not been examined for its effects on soybean grade or grade components. Criteria for soybean grade include damaged seed content, splits, and test weight. Seeds infected with P. sojae are distorted in size and shape and frequently are covered by a visible mycelial growth (moldy).

Since moldy seeds contribute to the damaged seed content, seed lots that are heavily infected with P. sojae may be downgraded. In U.S. No. I grade soybean seeds, moldy seed is limited to 2% or less; No. II to 3%; No. III to 5%; No. IV to 8%; and sample grade to above 8% (25). The grade and moldy seed content of Wells soybeans harvested at the University of Illinois Research Farms from four separate plots in 1975, 1976, and 1977 were: IV—6%, sample—11%; IV—8%, and sample—9%; 1—0%, 1—1%, 1—1%, and 1—0%; and III—4%, IV—6%, III—5%, and sample—12%, respectively. The seed lots from 1975 and 1976 were harvested 1 month after maturity, while the 1977 seed lots were harvested at maturity.

Phomopsis sojae symptomatic seed were lower than symptomless seed in seed weight, volume, and density and higher in induced splitting (Table 1). Phomopsis sojae can lower grade by reducing test weight and by increasing the number of split seeds. Workers have considered P. sojae unimportant for soybean production (1,13,19) or important only with regard to germination (10,27). We found that symptomatic seed could lower grade directly by increasing numbers of moldy beans or indirectly by lowering test weight or increasing the number of split seeds.

Human consumption of cooked soybeans and soy flour may help alleviate a global protein deficiency (6). Tropical climates high in rainfall and temperature are favorable for rapid development of seedborne P. sojae. In such areas, the adaptability of this crop may depend on the ability to produce acceptable seed quality, especially for production of high-quality food products. In Korea, P. sojae-infected pods were found unfit for vegetable use (20). Results of organoleptic tests of crude flour showed that symptomatic seed yielded a poor quality flour that may be unacceptable for human consumption (Table 2).

In the United States, most soybeans are crushed for oil. Historically, the oil has been worth more than the residue meal. Soybean oil must be colorless for acceptance in food products. Unrefined oil is normally clear amber after meal. Soybean oil quality also was shown to be lower in Aspergillus-infected soybean seeds than in noninfected seeds (17).

The soybean seedcoat accounts for only about 8% of the total dry weight of the seed and contributes little to oil and protein content. Nevertheless, the seedcoat structure is vital to preserve seed quality. Dehulling oil seed causes the rapid deterioration of their lipids (3). An intact seedcoat prevents atmospheric exposure and slows oxidation of lipids. The effects of P. sojae on seed quality dramatized the importance of the seedcoat in seed quality maintenance. Phomopsis sojae preferentially colonizes seedcoat tissues (15,23). Much of the fissuring and flattening of symptomatic seed probably is due to fungus breakdown of the seedcoat. Phomopsis sojae infection may remove the protective value of seedcoat tissues effectively, resulting in general loss of quality. Preferential use of seedcoat tissues by P. sojae may account for changes in protein and oil contents of symptomatic seeds (Table 2).

The value of soybean seed treatment has been judged for its ability to increase stand without regard to control of seedborne microorganisms and their role in spreading disease (2). Tiffany (24) reported that seedborne Colletotrichum dematium var. truncatum not only caused damping-off in soybeans but also was transmitted to adult plants by symptomless seedborne infections.

<p>| TABLE 1. Grade-related components of Wells soybean seeds with or without symptoms of Phomopsis sojae |</p>
<table>
<thead>
<tr>
<th>Seed lot</th>
<th>Weight a</th>
<th>Volume a</th>
<th>Density a</th>
<th>Splits b</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(g)</td>
<td>(ml)</td>
<td>(g/ml)</td>
<td>(%)</td>
</tr>
<tr>
<td>With symptoms</td>
<td>14.2*</td>
<td>22.4*</td>
<td>.63</td>
<td>7.8**</td>
</tr>
<tr>
<td>Without symptoms</td>
<td>16.7*</td>
<td>25.2*</td>
<td>.66*</td>
<td>1.4</td>
</tr>
</tbody>
</table>

aMeans based on 12 replications of 100 seeds each.

bMean number of split seeds after simulated grain handling on five replications. Data was transformed using square root transformation.

* and ** indicate statistical significance at P = 0.01 and 0.05, respectively, using FLSD test.
TABLE 2. Description of soybean flour and oil derived from Wells soybean seeds with or without symptoms of Phomopsis sojae

<table>
<thead>
<tr>
<th>Seed lot</th>
<th>Sensory evaluation of flour for “off” odor</th>
<th>Compositionb</th>
<th>Oil</th>
<th>Peroxide valuec</th>
<th>Dark color and “off” odor</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Oil (%)</td>
<td>Protein (%)</td>
<td>(%) (meq/kg)</td>
<td></td>
</tr>
<tr>
<td>With symptoms</td>
<td>Moderately pronouncedd</td>
<td>25.6**d</td>
<td>43.3*</td>
<td>125**</td>
<td>+c</td>
</tr>
<tr>
<td>Without symptoms</td>
<td>Slightly perceptible</td>
<td>23.0</td>
<td>42.4</td>
<td>52</td>
<td>−</td>
</tr>
</tbody>
</table>

*Mean category based on 15 panelists. †Mean based on 20 determinations. ‡Mean based on four determinations. ¶Indicates statistical significance at P = 0.05 and 0.01 level, respectively, using FLSD. §Qualitative observation: +, with dark color and off odor; −, without.

TABLE 3. Percentaged seed germination and percent recovery of Phomopsis sojae from Wells soybean seeds with and without symptoms of P. sojae, nontreated or treated with thiram fungicide

<table>
<thead>
<tr>
<th></th>
<th>Treatedb</th>
<th>Nontreated</th>
<th>Control with seed treatmentc</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Germination</td>
<td>% Recovery</td>
<td>Germination</td>
</tr>
<tr>
<td>With symptoms</td>
<td>20</td>
<td>34**</td>
<td>12</td>
</tr>
<tr>
<td>Without symptoms</td>
<td>91**</td>
<td>4</td>
<td>86**d</td>
</tr>
</tbody>
</table>

*Based on four replications of 100 seeds each. †Seed treatment consisted of application of Arasan 50 Red at 125 g/100 kg of seeds before planting. ‡Phomopsis control (C) = \[ \frac{(Phomopsis \, recovery \, without \, seed \, treatment) - (Phomopsis \, recovery \, with \, seed \, treatment)}{Phomopsis \, recovery \, without \, seed \, treatment} \times 100 \]

*** and * indicate statistically higher value at P = 0.01 and 0.05, respectively, using FLSD test.

Latent infections of P. sojae also have been found in soybeans (18). The importance of latent infections is unknown, but they likely contribute more to the disease development at the end of the season than do infections that kill young plants. In this study, low germination (12%) and high recovery of P. sojae on PDA were found for symptomatic seed. Seeds without symptoms had a high germination (86%) and 22% infection by P. sojae (Table 3). Seed treatment with thiram reduced P. sojae and increased germination in both seed types, but control of P. sojae was significantly greater in symptomless seeds. Soybean seed treatment has been considered necessary for “poor” quality seeds, ie, seeds with symptoms and germination below 80%, but not for “good” quality seeds, ie, seeds without symptoms and with a germination above 80%. Ignoring seed treatment of so-called good quality seed may work to perpetuate seedborne pathogens.

Agronomists, plant breeders, physiologists, and pathologists often describe soybean seed deterioration after a delayed harvest as “weathering” (3,8,12,21). Weathering is usually a problem under warm moist conditions, and the descriptions of “weathered” seed often are identical with symptoms caused by P. sojae. Little weathering was found after a delayed harvest when benomyl was applied at reproductive stages (8,11,16,26) and in cultivars resistant to seedborne infection (23,28). Therefore, we suggest that weathering is actually symptoms of infection by P. sojae and other seedborne fungi.

LITERATURE CITED


