Salvage of New York Soybean Seeds Following an Epiphytotic of Seedborne Pathogens Associated with Delayed Harvest

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ABSTRACT

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Thiram, carboxin plus thiram, benomyl plus thiram, and benomyl plus thiram plus streptomycin were compared as treatments for soybean seeds infested with *Phomopsis sojae* and *Fusarium* spp. Thiram and carboxin plus thiram generally improved germination and field emergence but did not increase yields in field tests. Benomyl plus thiram was most effective in increasing laboratory germination and field emergence. In field tests, soybean yields from seeds treated with benomyl plus thiram were 11% greater than yields from untreated seeds or seeds treated with thiram or carboxin plus thiram.

Soybeans ripened in wet weather in New York in 1977 and remained in the field for several weeks after maturity. These conditions fostered an epiphytotic of seedborne pathogens similar to those described by Wilcox et al (9) and Chamberlain and Gray (2). Germination in the seed lots averaged 54%; few lots tested above 80%, the minimum required for certification. In some lots, less than 20% of the seeds germinated.

The New York-grown seeds had to be salvaged because only limited amounts of seeds of adapted cultivars were available from other states. We attempted to identify the pathogens present, develop a seed treatment program to eradicate seedborne pathogens, and monitor the field performance of treated seeds.

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MATERIALS AND METHODS

Seed treatments. Seed treatments were as follows: Arasan 75 (75% thiram), 1.0 g/kg of seed; Benlate (50% benomyl), 1.5 g/kg; Benlate T (30% benomyl and 30% thiram), 2.5 g/kg; Benlate T plus streptomycin sulfate, 2.5 g/kg and 0.2 g/kg, respectively; and Vitavax 200 (17% carboxin and 17% thiram), 2.0 g/kg.

Germination tests. We tested soybean cultivars Altona (lots TC11 and TC18), Hodgson (lot JB10a), Rampage (CR23 and RD35), and Traverse (TC14). Initial germination tests were conducted on sterile paper towels in polycarbonate plastic boxes at 25 C with 12 hr light per day. Germination counts were recorded at 4 and 7 days. Germination tests were also conducted in rolled paper towels at 25 C for 8 days with 12 hr light per day (3). Four seed lots (Altona TC18, Rampage CR23 and RD35, and Traverse TC14) differing in germinability and incidence of infection were selected for seed treatment and field tests.

Enumeration of fungal pathogens. Two-hundred untreated seeds from each of the four seed lots were individually placed on moist blotters (3.0 × 3.5 cm). Six blotters were placed in each polycarbonate plastic box (10.5 × 14.5 cm), with at least 2.5 cm between blotters to reduce cross-contamination. Treated seeds were placed on blotters (16 × 23 cm) in polycarbonate boxes, with five replicates of 40 seeds per box for each treatment and seed lot. Seeds were observed for fungal growth after 10–14 days on laboratory benches at room temperature (22 C). Identification of fungi was based on cultural characteristics and spore morphology (8).

Field tests. For each seed lot and treatment, four randomized replicate plots of four rows each, 100 seeds per row, were planted in June 1978. The field had never been planted to soybeans, and oats were grown between plots to prevent cross-contamination. Emergence was counted 15 and 30 days after planting. Plots were examined weekly for disease symptoms. At maturity (15 September–15 October, depending on cultivar), plants

were cut from the center two rows of each plot, air dried, and threshed with a belt thresher. Seeds were weighed, counted, and tested for moisture and germination.

RESULTS

Seeds harvested in 1977 in New York were generally of poor quality. Germination was less than 50% in untreated seeds from six seed lots sampled (Table 1). Treatment with thiram or thiram plus carboxin usually improved germination but did not adequately control seedborne pathogens. Fungi frequently overgrew the test blotters and formed a solid mat of mycelium over seeds and blotters. Benomyl treatments, in most instances, raised germination rates and controlled fungal growth. In Rampage RD35 and Hodgson JB10a, where bacterial as well as fungal infection was recorded, the addition of streptomycin sulfate further improved germination.

Untreated seeds were heavily infested with many fungi, but *Phomopsis sojae* (*Diaporthe phaseolorum* var. *sojae*), the cause of pod and stem blight, and *Fusarium* spp. were the most prevalent. Species of *Alternaria, Aspergillus, Cercospora, Colletotrichum*, and *Pythium* were found less often.

P. sojae was identified on 29–49% of untreated seeds (Table 2). Treatment with thiram or thiram plus carboxin usually reduced the incidence of detectable *P. sojae*, but benomyl plus thiram treatments completely inhibited growth of this organism on test blotters. A small amount of mycelial growth similar to *P. sojae* appeared on a few seeds treated with benomyl plus thiram, but no spores were produced and positive identification was not possible.

Fusarium spp. were identified on up to 14% of untreated seeds. Benomyl treatments were more effective than thiram or thiram plus carboxin in controlling these organisms (Table 2).

Seed treatments were also compared in the field, where warm temperatures and adequate moisture resulted in rapid emergence. Thiram plus carboxin, benomyl plus thiram, and benomyl plus thiram plus streptomycin treatments significantly improved emergence (Table 2). Thiram alone was less effective. Slight chlorosis was noted along the edge of cotyledons in the thiram plus carboxin treatments.

No severe disease problems developed in any test plot during the relatively dry growing season, but at crop maturity, pycnidia of *Phomopsis* could be seen on some senescent stems regardless of treatment. The harvested seeds, generally of very good quality, showed no significant differences in germination among treatments. More than 90% of the untreated seeds germinated on average (Table 3). In general, less than 3% of the harvested seed was diseased.

Yield data were difficult to interpret

Table 1. Percent germination[y] of treated soybean seeds

Treatment[z]	Seed lot: Rampage RD35	Rampage CR23	Traverse TC14	Altona TC18	Altona TC11	Hodgson JB10a
None	6 a	43 a	12 a	16 a	18 a	7 a
Thiram	11 ab	89 bc	33 b	52 c	64 c	17 b
Thiram/carboxin	18 b	85 b	29 b	41 b	28 b	18 b
Benomyl	44 d	92 cd	56 c	83 d	87 d	37 d
Benomyl/thiram	32 c	95 d	75 d	88 d	87 d	28 c
Benomyl/thiram streptomycin	60 e	94 cd	69 d	88 d	89 d	55 e

[y]Counts after 1 wk on sterile, moist paper towels in polycarbonate boxes at 25 C, 12 hr light per day. Values with dissimilar letters are significantly different according to Waller and Duncan's BSD test ($K = 100$).
[z]Treatment rates (g a.i./kg of seed): thiram 0.75;, thiram/carboxin 0.34/0.34; benomyl 0.75;, benomyl/thiram 0.75/0.75; streptomycin 0.2.

Table 2. Incidence of *Phomopsis sojae* and *Fusarium* spp. and field emergence in four soybean seed lots after seed treatment

Seed lot	Treatment[z]	Incidence of microorganisms (%)[y]: *P. sojae*	*Fusarium* spp.	Field emergence (%)
Rampage CR23	None	29 a	4 a	91 a
	Thiram	2 b	1 b	92 a
	Thiram/carboxin	2 b	1 b	92 a
	Benomyl/thiram	0 b	0 b	94 a
	Benomyl/thiram/streptomycin	0 b	0 b	93 a
Rampage RD35	None	34 a	14 a	45 a
	Thiram	35 a	11 a	41 a
	Thiram/carboxin	32 a	9 b	53 b
	Benomyl/thiram	0 b	0 c	50 b
	Benomyl/thiram/streptomycin	0 b	0 c	52 b
Traverse TC14	None	40 a	7 a	62 a
	Thiram	16 b	3 ab	67 b
	Thiram/carboxin	11 c	4 a	75 c
	Benomyl/thiram	0 d	0 b	73 c
	Benomyl/thiram/streptomycin	0 d	0 b	72 c
Altona TC18	None	49 a	1 b	76 a
	Thiram	11 b	3 a	82 ab
	Thiram/carboxin	6 c	1 b	86 b
	Benomyl/thiram	0 d	0 b	85 b
	Benomyl/thiram/streptomycin	0 d	0 b	86 b

[y]Values with dissimilar letters are significantly different according to Waller and Duncan's BSD test ($K = 100$).
[z]Treatment rates (g a.i./kg of seed): thiram 0.75; thiram/carboxin 0.34/0.34; benomyl/thiram 0.75/0.75; streptomycin 0.2.

Table 3. Yield and germination of soybeans from treated seeds

Treatment[w]	Seed lot: Rampage RD35 Yield[x,z]	Rampage RD35 Germ.[y,z]	Rampage CR23 Yield	Rampage CR23 Germ.	Traverse TC14 Yield	Traverse TC14 Germ.	Altona TC18 Yield	Altona TC18 Germ.	Mean yield	Mean germ.
None	692 a	92 a	901 a	94 a	683 a	91 a	665 a	88 a	735 a	91 a
Thiram	595 a	89 a	891 a	92 a	748 a	95 a	695 a	91 a	732 a	92 a
Thiram/carboxin	655 a	86 a	889 a	95 a	775 a	94 a	612 a	91 a	733 a	92 a
Benomyl/thiram	668 a	92 a	958 a	93 a	823 a	96 a	870 a	92 a	830 a	93 a
Benomyl/thiram/streptomycin	802 a	93 a	889 a	94 a	717 a	94 a	815 a	91 a	806 a	93 a

[w]Treatment rates (g a.i./kg of seed): thiram 0.75; thiram/carboxin 0.34/0.34; benomyl/thiram 0.75/0.75; streptomycin 0.2.
[x]Total grams, dry weight.
[y]Percent.
[z]Values followed by dissimilar letters are significantly different according to Waller and Duncan's BSD test ($K = 100$).

because feeding deer caused large plot-to-plot variations. The benomyl treatments usually gave the greatest yields, but this difference was not statistically significant.

An emergency 24(C) registration for use of a benomyl plus thiram seed treatment in New York in 1978 was obtained, and most New York-grown soybean seeds planted in 1978 were so treated. An acceptable commercial crop was produced—the average yield was 23 bu/acre, compared with 23 bu/acre in 1977 and 26 in 1976 (1).

DISCUSSION

Delayed harvest often results in increases of seedborne fungi, particularly *Phomopsis* spp., and a corresponding decrease in seed germination (4,6,7,9). Benomyl foliar sprays can reduce the proliferation of seedborne fungi in soybeans harvested after maturity and thus maintain acceptable quality (4). Our results indicate that benomyl plus thiram seed treatments may be used to salvage poor-quality soybean seeds harvested after maturity. The differences between untreated and treated seed performance, although less striking in the field than in the laboratory, were significant.

Seeds may perform better in the field than in laboratory tests for several reasons. First, excellent spring weather conditions contributed to rapid emergence and better-than-expected performance of untreated seeds. Second, accurate estimation of seed germination potential is often difficult in the laboratory because fungi and bacteria frequently spread from seed to seed on test blotters, especially when seeds are of poor quality. In such cases, use of fungicides or antibiotics helps reduce microbial overgrowth and improve germination counts. The physical separation of seeds in the soil minimizes the effects of microorganisms from neighboring seeds. Third, soil microflora may compete with microorganisms on the seed and reduce the growth of seed pathogens.

New York's dry growing and harvest season of 1978 resulted in high-quality soybean seeds by preventing proliferation of pathogens, which is usually associated with high humidity. Although yields from untreated and treated seed lots were not statistically different, the greatest yields for each cultivar were in plots from seeds treated with benomyl plus thiram, which yielded an average 11% more than plots from untreated seeds or seeds treated with thiram or thiram plus carboxin.

In summary, diseased seeds with low laboratory germination may be used, as a last resort, with proper treatment. Both fungicides and insecticides should be used in areas with seed maggots, because diseased or damaged seeds may support greater microbial activity and thus be more attractive to seed maggots than healthy seeds (5).

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