Performance of Foliar Fungicides on Soybeans in Georgia

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ABSTRACT

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Potential benefits of foliar fungicides on soybeans were examined in a series of 77 experiments over a 10-yr period at several locations in Georgia, using cultivars of different maturity groups planted as a full-season or second crop. Levels of damaging diseases were usually low, and in more than 90% of these experiments, no significant yield increase was obtained from a foliar fungicide. Increases in percentage of germination of harvested seed occurred less frequently than increases in yield. A decreased incidence of disease was measured in 27% of the experiments, but there was no consistent association between reduced disease and increased yield or seed germination. The only consistent effect of applying foliar fungicides was a delay in maturity of the soybeans. Yield, maturity group of the soybean cultivar planted, location, or planting date were of little value in predicting experiments in which a yield increase was most probable. The current low level of usage of foliar fungicides on soybeans in the Southeast seems to be consistent with the benefits to be expected from their use.

In the early 1970s, many southern farmers who routinely used fungicides for peanut leaf spot control started planting significant acreages of soybeans. Reports from these farmers that soybeans sprayed with fungicides remained green after unsprayed soybeans matured led to extensive research on the use of foliar fungicides on soybeans. Yield increases from using foliar fungicides (hereafter referred to as fungicides) on soybeans have been reported (2,3,8,9,12,13). Several fungicides are now registered for use on soybeans, and in recent years, advertising in the South has been extensive in many early-summer issues of farm magazines or newspapers.

Although the magnitude of the reported (2,3,8,9,12,13) and advertised yield increases would make fungicide application profitable, there is only one report (2) on the frequency with which such yield increases can be expected. The authors did not specify the frequency of significant yield increases but indicated that yield increases were larger and more frequent in wet than in dry seasons. Because yield increases from foliar fungicides have been erratic (2) and unpredicable in many areas, prediction systems designed to assist the grower in making a decision on fungicide use have been developed in several states. These systems have the common problem that the decision must normally be made at the R_3 growth stage (6), before important factors such as weather and disease development late in the season can be determined. Therefore, information on the frequency as well as the magnitude of responses in previous years is essential if an informed decision on the use of fungicides is to be made. This paper summarizes the frequency and magnitude of benefits obtained by using fungicides on soybeans in Georgia during the past 10 yr.

MATERIALS AND METHODS

All experiments were arranged in randomized complete blocks with three, four, or five replicates. In 70 experiments, fungicides were applied in 187 L of water per hectare with a plot sprayer equipped with three nozzles per row, operating at 4.9–5.3 kg/cm^2. The nozzles were suspended from an adjustable, tractor-mounted boom that could cover as many as four rows without driving the tractor in the plot area. Undisturbed eight-row plots were obtained by spraying two adjacent sets of four rows. Four-, six-, or eight-row plots 9–15 m long were used in these experiments. All data were taken on the interior two, four, or six rows.

In seven experiments, fungicides were applied with fixed-wing aircraft calibrated to deliver 47 L/ha of spray mixture. Plot

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size ranged from 0.4 to 2.0 ha.

The cultivars Dare, Coker 136, Tracy, or Davis from maturity groups 5 and 6 were planted in 20 experiments. Bragg or Ransom from group 7 were planted in 35 experiments. The cultivars Hutton, Hampton 266A, Coker 338, or Cobb from group 8 were planted in the remaining 22 experiments.

Most fungicides were applied at the late-bloom/early pod-set stage and again 14–21 days later (R_3 and R_5 as outlined by Fehr et al [6]). When three applications of chlorothalonil were made, they were done at early flowering and 14 and 28 days later.

Four fungicides currently registered for use on soybeans, (benomyl, chlorothalonil, thiabendazole, and thiophanate-methyl) as well as fentin hydroxide were included in the data presented. Only rates or timings consistent with label restrictions were included. Fentin hydroxide, which is in the registration process, was considered to have the same label restrictions as benomyl.

The 32 experiments in west central Georgia were in eight fields in Pike and Spalding counties. The 14 experiments in southeast Georgia were in four fields in Burke County. The 31 experiments in southwestern Georgia were in 15 fields in Tift, Sumter, Lowndes, Worth, Mitchell, and Brooks counties.

Sixty-one experiments were considered full-season plantings, ie, they were planted before small grain had been harvested in that area. These planting dates ranged from 5 May to 6 June. The remaining 16 experiments were not planted until after small grain had been harvested. These planting dates ranged from 6 to 28 June.

Plots were harvested with a small combine, the seed cleaned of debris, weighed, and the percentage of moisture determined. Yield is presented at 13% moisture. A sample of seed from each plot in 62 of the experiments was sent to the Georgia Department of Agriculture Seed Laboratory for germination testing by the standard Association of Official Seed Analysts procedure (1).

Maturity was rated in 33 experiments when most plants in untreated plots had lost their leaves. Each plot was rated on a scale of 1–3, where 1 = maturity equal to untreated areas, 2 = slightly less mature than untreated areas, and 3 = definitely less mature than untreated areas.

At least one type of disease rating was made in 56 of the experiments. In several experiments, two or more were made. The number and type of disease rating were dependent on disease development in each experiment. In 45 experiments, the degree of discoloration of stems and pods, caused primarily by *Diaporthe phaseolorum* var. *sojae*, was determined. A sample of stems and pods taken from each plot at harvest was dried and ground in a Wiley mill. Three subsamples from each plot were read on a Gardner color difference meter on a scale of 0 (black) to 100 (pure white). In eight experiments, purple seed stain was severe enough to permit a count of discolored seed. In seven experiments, 50 pods and/or seeds per plot were surface-sterilized, plated on potato-glucose agar, and the emergent fungi enumerated. In five experiments, each plot was rated for powdery mildew on a scale of 0 (no mildew) to 5 (leaves entirely covered with mildew). In several experiments, attempts were made to determine the incidence of each of several leaf spot diseases (frogeye leaf spot, brown spot, anthracnose, and downy mildew) by taking random leaf samples and counting lesions. In each case except one, this effort was abandoned because of the low infection level and erratic distribution of the diseases. In one experiment, downy mildew lesions were counted in each plot.

Yield, seed germination, disease ratings, and maturity ratings were subjected to analysis of variance, and the means were compared by Duncan's new multiple range test ($P = 0.05$).

RESULTS AND DISCUSSION

The frequency of significant responses to fungicides for all experiments combined and for experiments grouped by several criteria is shown in Table 1. Increases in yield or seed germination were rarely obtained, a decrease in disease rating occurred somewhat more frequently, and a significant delay in maturity occurred regularly with fungicide application.

Yield increases occurred in only seven of 77 experiments. The yield level of the experiment, location, or planting date had little influence on the frequency of yield increases (Table 1). Cultivars in the midseason-maturity group 7 were planted in six of the seven experiments where yield increases were obtained. No yield increases were obtained with cultivars in the early-maturity groups 5 and 6.

The price of fungicides and soybeans and application costs are highly variable, but at current prices, an average of 200 kg/ha in increased yield is needed to offset the cost of two applications of a fungicide. In the few instances when a significant yield increase was obtained, the increase was in the range where the increased return was about twice the cost of application. When all experiments are considered, however, the increased return averaged about one-half or less of the cost of fungicide application (Table 2). The mean yield increase (188 kg/ha) reported for benomyl in 33 experiments in Alabama (2) was slightly higher than that obtained in the 75 experiments reported

Table 1. Frequency of experiments in which foliar fungicides, applied to soybeans at rates and timings consistent with label restrictions, caused a significant effect on yield, seed germination, disease, or maturity

Grouping	Yield increase[a]	Seed germination increase[b]	Disease rating decrease[c]	Maturity delay[d]
All experiments combined	7/77[e]	5/62	15/56	30/33
Experiments grouped by:				
Yield level				
Low (<1,700 kg/ha)	2/17	1/10	3/7	6/6
Medium (1,700–2,700 kg/ha)	4/44	4/39	10/36	21/23
High (>2,700 kg/ha)	1/16	0/13	2/13	3/4
Maturity group				
Early (groups 5 and 6)	0/20	2/18	9/19	10/12
Midseason (group 7)	6/35	2/24	2/19	11/12
Late (group 8)	1/22	1/20	4/18	9/9
Location				
West central	4/32	2/24	10/23	22/24
Southeast	1/14	1/14	2/14	1/1
Southwest	2/31	2/24	3/19	7/8
Planting date				
Full season	6/61	4/46	15/42	26/29
Double crop	1/16	1/16	0/14	4/4
Fungicide				
Benomyl	3/75	4/61	12/55	28/31
Chlorothalonil	2/61	1/55	2/51	22/26
Fentin hydroxide	2/23	1/14	6/9	9/12
Thiabendazole	1/21	0/15	6/9	7/10
Thiophanate-methyl	0/6	0/4	1/5	2/4

[a] Weight of seed obtained by combining the interior two, four, or six rows from four-, six-, or eight-row plots 9–15 m long (replicated three, four, or five times).
[b] Germination percentage determined on a sample from each replicate plot by the standard Association of Official Seed Analysts technique.
[c] Several types of disease ratings were made; see text.
[d] Each replicate plot rated on a scale of 1–3 for delay in maturity compared with untreated areas in the same field.
[e] Each entry = number of experiments in which any fungicide caused a significant ($P = 0.05$) increase or decrease compared with the control/number of experiments in which data were obtained.

Table 2. Influence of foliar fungicides, applied to soybeans at rates and timings consistent with label restrictions, on yield of soybeans in Georgia

Fungicide	No. of experiments[a]	Mean yield of control (kg/ha)	Mean yield of treatment (kg/ha)	Increase over control (kg/ha)
Benomyl	75	2,154.7	2,267.4	112.7
	(3)[b]	(2,258.4)	(2,703.7)	(445.3)
Chlorothalonil	61	2,255.7	2,315.6	59.9
	(2)	(1,588.8)	(2,098.8)	(510.0)
Fentin hydroxide	23	1,917.6	2,024.1	106.5
	(2)	(1,760.1)	(2,188.3)	(428.2)
Thiabendazole	22	1,908.2	1,988.3	80.1
	(1)	(2,559.2)	(2,981.0)	(421.8)
Thiophanate-methyl	6	2,141.2	2,173.1	31.9

[a] Total number of experiments in which data were obtained for the indicated fungicide at any rate or timing consistent with label restrictions for soybeans. Fentin hydroxide, not currently labeled for soybeans, was considered to have the same label restrictions as benomyl.

[b] Numbers in parentheses are from only those experiments in which the indicated fungicide caused a significant ($P = 0.05$) increase in yield compared with the control.

Table 3. Estimates of foliar fungicide usage on soybeans in 1976, 1980, and 1982 based on USDA surveys[a]

Region	Percentage of soybean acreage treated with foliar fungicides		
	1976	1980	1982
Southeast[b]	5.0%	2.3%	0.5%
Delta[c]	9.0%	4.4%	2.0%

[a] Data from Duffy (4), Eichers et al (5), and Hanthorn et al (7).

[b] Includes Georgia, South Carolina, and Alabama; Florida also was included in 1976.

[c] Includes Mississippi, Louisiana, and Arkansas.

in this paper (Table 2).

Seed harvested from fungicide-treated plots had a higher germination rate than seed from control plots in only five of 62 experiments. Yield level of the experiment, maturity group of the cultivar planted, location, or planting date had little influence on the frequency of germination increases (Table 1).

Decreases in some disease ratings were measured in 15 of 56 experiments. They were considerably higher than increases in either yield or germination; however, there was no consistent relationship between reduced disease rating and increased yield or seed germination. A reduced disease rating was accompanied by an increased yield in only two experiments and by increased seed germination in only two experiments. A reduced disease rating accompanied by both increased yield and seed germination was observed in only one experiment. Kittle and Gray (11) also reported decreased disease levels without a yield increase in fungicide-treated plots.

The higher frequency of disease decreases on cultivars in maturity groups 5 and 6 was a result of control of purple seed stain on these cultivars. Purple stain was usually not a problem on later-maturing cultivars. The apparently higher frequency of disease decreases in experiments conducted in the west central region was partially a result of powdery mildew control. Powdery mildew-susceptible cultivars were planted in five experiments in the west central region compared with only one experiment in each of the other regions.

The low frequency of yield increases apparently reflects the low frequency of potentially damaging diseases controllable with fungicides. Frogeye leaf spot, brown spot, and anthracnose, reported to cause losses (2,3,9,12), were often observed at very low levels, but were so erratically distributed that meaningful disease ratings could not be made. There was a close relationship between disease development and yield in only one experiment in which fungicides increased yield. In that experiment, yield was inversely correlated with the powdery mildew rating (D. V. Phillips, *unpublished*). In three other experiments, fungicides reduced powdery mildew levels but did not increase yields.

The only consistent effect of application of fungicides to soybeans was a delay in maturity. In most experiments, this delayed harvest by 4–5 days or less. In some extreme cases, harvest was delayed as long as 14 days by green stems and retained leaves; in these cases, the pods matured much sooner than the stems. Although this delayed maturity may be related to disease control (2,10), the results of this study agree with the observation by Ross (12) that delayed maturity is not necessarily beneficial to yield.

The frequency of experiments in which any fungicide caused a yield or germination increase was low, but the frequency of response to each fungicide was even lower (Table 1). Comparisons among fungicides can best be made in experiments when all are included, but on the basis of data in Tables 1 and 2, it appears that there were no major differences in the performance of the fungicides used.

It is obvious that indiscriminate use of fungicides on soybeans in Georgia during the last 10 yr would have been highly unprofitable. Therefore, it would be helpful to growers to be able to identify situations where use of fungicides is most likely to be profitable. Yield level (at least potential yield), maturity group of the cultivar planted, location, and planting date are factors that can be determined before the time when fungicides must be applied and thus might be useful predictive criteria. From the data presented in Table 1, it appears that fields with a yield level below 2,700 kg/ha planted with a midseason cultivar as a full-season planting in west central Georgia would have the highest probability of a yield increase from fungicides. During this study, 12 experiments satisfied all of these criteria. Because a yield increase was obtained in only one of these 12 experiments, these criteria apparently are of little predictive value.

In three USDA surveys (4,5,7), the two regions with the highest rate of fungicide use on soybeans were the southeast and Delta. From the data in Table 3, it is apparent that for these two areas, use of fungicides on soybeans was never extensive and has declined substantially in recent years. Perhaps growers in these regions have obtained responses similar to those reported in this study.

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