Comparison of Meteorological and Standardized Timings of Fungicide Applications for Soybean Disease Control

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ABSTRACT

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Results from soybean foliar disease-control tests conducted over 4 yr indicate that the standard two-spray program required 33% more fungicide applications than an application-timing system based on rainfall frequency. Fungicide applications for the meteorological system were made to more appropriately coincide with infection periods; numbers of fungicide applications ranged from zero to three. The standard program did not return the cost of treatment 50% of the time, whereas the meteorological system always resulted in a positive dollar return over the cost of control.

Foliar diseases of soybean (*Glycine max* (L.) Merr.) can cause significant yield losses in the southeastern United States, as evidenced by responses to foliar fungicides (1,5,8). The critical period for development of yield-damaging levels of most foliar diseases occurs between bloom and full pod (6). Most fungicides registered and labeled for use on soybeans require two applications during this period. Backman et al (1) determined that fungicides applied during droughts did not improve yield because damaging levels of diseases did not develop under such conditions. Since that time, several states (Alabama, Arkansas, Mississippi, and Kentucky) have recommended "point systems" based on environment, weather history, cultural history, and/or cultivar (4,7) to more accurately determine when fungicide applications would be effective and profitable. Data reported by Davis and Sakamoto (2) indicate that the 50% probability for July thunderstorm days in the southeastern United States varies from 8 to 21 days, depending on location. Frequency of thunderstorms and weather changes from month to month (Table 1) can profoundly affect the intensity and severity of disease development (1). The purpose of this study was to evaluate a fungicide-scheduling system based on rainfall frequency in comparison to the standard two-spray program.

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MATERIALS AND METHODS

Tests were conducted throughout the drier northern regions of Alabama to evaluate the meteorological timing system described. In all, six tests were conducted covering 4 yr and four locations. When soybeans reached early bloom (R_1) (3), rainfall at the test location was recorded. After 3–4 wet days (infection day = rain >2 mm or extended periods of fog or dew) had been recorded, the first fungicide application was made. This usually coincided with early pod set (R_3) but occasionally was earlier if a very wet period occurred during bloom. When three additional wet days were recorded subsequent to the first application, a second application was made 12–20 days after the first. The second application was omitted if within 20 days of the first application, insufficient wetness (<3–4 infection days) had accumulated. During particularly wet periods, the spray interval was reduced to a 10-day interval to compensate for increased weathering of the fungicide and frequent occurrence of wet infection periods.

All six tests contained the following treatments: 1) no fungicide; 2) benomyl 50WP, 0.56 kg/ha applied at R_3 (early pod set) and R_5 (pod fill) (standard program); and 3) benomyl 50WP, 0.56 kg/ha applied according to existing meteorological conditions described earlier. In the 1982 test, three additional fungicides were evaluated by the same standard and meteorological timing techniques: chlorothalonil, 500 g/L flowable applied at 2.3 L/ha; thiophanate methyl 70WP applied at 560 g/ha; and propiconazole (CGA-64250), 430 g/L, EC applied at 400 ml/ha. All treatments were arranged in randomized complete blocks and were represented with six replicates per location per year. Various cultivars were used on a yearly basis.

The year, location, cultivar, and maturity grouping for each test were: 1982 (Belle Mina), Essex, V; 1981 (Marion), Coker 156, VI; 1981 (Belle Mina), Essex, V; 1980 (Belle Mina), Essex, V; 1980 (Ashford), Hutton, VIII, and Ransom, VII; and 1978 (Crossville), Essex, V. Small plot tests were four rows (0.9-m row spacing) by 10 m, with all rows sprayed with a high-clearance sprayer operating at 6 kg/cm^2 and delivering 40 L/ha. The single air trial (Ashford, AL) had large plots (50 × 50 m) replicated twice for each cultivar, with each plot subsampled three times.

In all experiments, disease severity was determined just before senescence (R_7) for brown spot (caused by *Septoria glycines* Hemmi) and before harvest (R_8) for anthracnose (caused by *Colletotrichum truncatum* (Schw.) Andrus & Moore) by subjective rating scales reported previously (1). Other diseases were rated but did not occur at significant levels. Yields (dry seed per hectare) were made from the center two rows of small plots with conventional soybean harvesters and from three locations in each plot for the air trial.

To determine the economic impact of the various spray programs, May 1983 prices were used for soybeans ($240/tonne) and for benomyl application costs ($21.00/application per hectare, includes product and application costs). Data are presented as treatment means, except for 1982, which represents the mean of all four fungicides evaluated within each spray schedule.

RESULTS AND DISCUSSION

The meteorological timing system reduced the number of fungicide applications by an average of 33%, whereas the frequency of nonprofitable fungicide applications was reduced from 50% to zero for the standard program (Table 1). Control of brown spot and anthracnose, however, was only slightly inferior to that in the standard program (*unpublished*).

Economics data indicate that not only was the number of locations with noneconomic return on fungicide investment reduced when the meteorological timing system was used but all locations gave positive dollar return above cost (Table 1). The ratio of increased crop value to cost of control was very positive for the meteorological program ($2.63/1.00 invested) and only marginally beneficial for the standard program ($1.17/1.00 invested).

These data indicate that although foliar diseases can cause substantial losses in soybeans, control measures cannot be used routinely at standardized times with the expectation of reasonable return on investment. The system described in this paper for applying benomyl is based on the probability of damaging levels of disease developing during rainfall periods; this system reduced total pesticide application by 33%, yet achieved a greater dollar return per hectare in five of six experiments. Control of both brown spot and anthracnose was comparable for both systems, even with the disparity in fungicide usage.

Some of the success of the meteorological system can be related to the systemic nature of benomyl (also the thiophanate methyl and propiconazole tested in 1982). The "kickback" activity of these products allow for therapeutic removal of established infections. Furthermore, we were able to utilize observed weather rather than predicted weather. If contact fungicides were used, spray applications would probably be made before infection periods as protectants and predicted weather would have to be utilized.

The meteorological spray-timing system was developed for control of soybean diseases in the southeastern United States and should not be extrapolated to other areas with differing climates and disease spectra. Triggers for the meteorological system can be adapted for changing economic realities; if the

Table 1. Meteorological and standard timing of foliar fungicide applications to soybeans compared with unsprayed soybeans for effects on yield and dollar return per hectare[a,b]

		Meterological program			Standard program		
Location (yr)	No treatment (yield, t/ha)	Time and no. of sprays[c]	Yield (t/ha)	Return/ha[d] ($)	Time and no. of sprays	Yield (t/ha)	Return/ha ($)
Belle Mina (1982)	2.634	R_2R_4	3.011	48.48	R_3R_5	2.843	8.16
Marion (1981)	1.395	None	1.395	0	R_3R_5	1.415	−37.20
Belle Mina (1981)	2.527	$R_2R_4R_5$	3.073	32.28	R_3R_5	2.857	37.20
Belle Mina (1980)	2.406	R_3	2.628	32.28	R_3R_5	2.453	−30.72
Ashford (1980)[e]	2.568	R_3	3.060	97.08	R_3R_5	3.087	82.56
Crossville (1978)	2.507	R_3	2.648	12.84	R_3R_5	2.615	−16.08
Mean	2.340	1.3X	2.636	$43.12	2X	2.545	$7.32
Value	$561.60	$27.30	$632.40	$70.80[e]	$42.00	$610.80	$49.20[f]
Increased $ value/$ invested			$2.63/1.00			$1.17/1.00	

[a] Standard timings were sprayed at early pod set and pod fill; meteorological applications were made only when 3–4 days with >2 mm of rain was recorded during the bloom to pod-fill interval as described in text.
[b] Mean of benomyl alone each year except 1982, where mean is of benomyl, chlorothalonil, propiconazole, and thiophanate methyl.
[c] Spray timings: R_1 = early bloom, R_2 = full bloom, R_3 = early pod set, R_4 = late pod set and elongation, and R_5 = pod fill.
[d] Dollar return/ha = [t/ha × $240 − (no. applications) × $21]. This return assumes metric ton value of soybeans = $240 and cost of application = $21/treatment (May 1983 values).
[e] Aerial application, data is average for two cultivars.
[f] Average net return = yield value in dollars for the treatment minus yield value of untreated control (eg, $632.40 − 561.60 = $70.80 net).

value of soybeans should rise, fewer infection days would be required to trigger a fungicide application. Using similar logic, if the price of benomyl should rise, the number of infection days required to trigger a spray treatment could be increased.

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