Yield Losses in Soybeans from Anthracnose Caused by *Colletotrichum truncatum*

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ABSTRACT

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Three soybean (*Glycine max*) cultivars, Bragg, Essex, and Hutton, were evaluated for yield losses resulting from anthracnose caused by *Colletotrichum truncatum*. Field plots of each cultivar were established in an area naturally infested with *C. truncatum* and were subsequently sprayed with fungicides that differed in efficiency of disease control. The effect of anthracnose severity on seed yield was estimated by quadratic or linear regression. Estimates of maximal reductions in seed yield due to anthracnose ranged from 16 to 26% for the three cultivars and averaged 19.7%. Yields were typically reduced as the soybean pods became infected with *C. truncatum*.

Soybean (*Glycine max* (L.) Merr.) yield losses resulting from stem and foliar diseases are poorly documented (4). Horn et al (3) evaluated soybean yield losses following greenhouse inoculation of three cultivars and reported that *Corynespora cassiicola* (Berk. & Curt.) Wei caused greatest yield losses, followed in decreasing order by *Cercospora sojina* Hara and *Diaporthe phaseolorum* (Cke. & Ell.) Sacc. var. *sojae* (Lehman) Wehm. Young and Ross (9) inoculated field-grown soybeans with *Septoria glycines* Hemmi at various dates and were able to detect a significant yield reduction in one of four experiments. Similar studies were carried out by Pataky and Lim (5).

Backman et al (1) evaluated several field-grown, naturally infected cultivars of soybeans and determined that significant increases in yield and significant reductions in several diseases resulted from applications of fungicides. No attempt was made to quantify the yield loss contribution of the individual diseases. However, *Colletotrichum truncatum* (Schw.) Andrus & Moore (= *C. dematium* (Fr.) Grove f. *truncata* (Schw.) Arx) was reported to be slightly more damaging than *S. glycines*, which in turn was more damaging than *Cercospora sojina*. In the 33 tests reported, significant increases in yield were recorded whenever *C. truncatum* damage was reduced by fungicides.

Although significant losses of soybean yields are often attributed to *C. truncatum* (7), a definitive relationship between disease severity and yield has not been established. It was the objective of this study to determine this relationship for several soybean cultivars representative of those commonly grown in the southeastern United States.

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MATERIALS AND METHODS

Each year, we perform numerous soybean disease control experiments at various locations in Alabama. Sites for the present study were selected from a large number of possible locations and were judged to have soybeans almost exclusively infected with *C. truncatum*. This judgment was based on evaluation of disease control experiments that had already been performed and followed frequent on-site disease severity ratings conducted at each potential test location. We recognize, however, that other foliar diseases did occur, but at very low levels. Essex, Bragg, and Hutton cultivars of soybean, representing maturity groups V, VII, and VIII, respectively, each planted at a different location, were found to meet the selection criterion. All locations selected were planted in soybeans the previous year to assure maximum disease development. Disease severity was manipulated by pesticides to allow disease severity ratings to be related to yield (6).

The following pesticides were used: benomyl 50 WP, 0.56 kg/ha; fentin hydroxide 47 WP, 0.56 kg/ha; thiabendazole 42.3% flowable, 0.74 L/ha; captafol 39.0% flowable, 2.25 L/ha; carbaryl 50 WP, 1.12 kg/ha (insecticide check); and an untreated control. The relative efficacy of these pesticides for control of anthracnose has been documented (1). Pesticides were applied when pods began to form at the R_3 and R_5 stages of development (2) with a high-clearance ground sprayer operating at 6 kg/cm^2 and delivering 40 L/ha. At each location, treatments were arranged in a randomized block design with eight replicates.

Anthracnose severity was determined following plant senescence (total defoliation with stems dry). The following subjective scale based on the degree of stem and pod involvement with the typical, black setae-containing acervuli was used for this rating: 1.0, no visible signs of infection; 2.0, lower half of stems infected, first signs of infection on upper half, pods clean; 3.0, stems completely infected, first signs of disease on terminal pods; 4.0, stems completely infected, terminal half of pods infected, some infection on lower pods; and 5.0, stems and pods totally infected. Ratings were made to the tenth unit for close approximation of observable differences. The potential of anthracnose to cause petiole infections leading to defoliation and pod infections leading to blanking (empty pods) was recognized, but the rating system used is considered to integrate earlier disease severity into this end-of-season rating.

Immediately after the postsenescence disease rating, plots were harvested using a two-row combine, and dry seed yield per hectare was determined. Disease and yield data were subjected to regression analysis (8).

RESULTS

Severe levels of anthracnose developed on all untreated soybean cultivars. Fungicide treatments produced a broad range of disease severities within locations. Seed yields were inversely and significantly related to the severity of the anthracnose infections (Fig. 1) of cv. Essex and Hutton ($P = 0.01$) and Bragg ($P = 0.05$), validating the severity scale used. The relationship of disease to yield loss was clearly visible in the scattergrams for all cultivars. Because the disease severity × yield relationship is plotted for each plot, scatter is more apparent than if treatment means were plotted. Average decreases in seed yield as severity of anthracnose increased were determined by quadratic and linear regressions; the curves are superimposed on the scattergrams. For Hutton and Bragg cultivars, best fit was achieved using quadratic regression; for the Essex cultivar, the linear regression produced the most significant relationship.

Using the regression lines to compare soybean yields (Fig. 1) at maximal and minimal values of anthracnose severity, a

26% loss for Essex, a 16% loss for Bragg, and a 17% loss for Hutton were indicated. Because anthracnose was most severe in untreated plots and least severe in plots treated with benomyl or fentin hydroxide, these percentages also reflected preventable losses using currently available technology. The average preventable loss in the three cultivars tested was 19.7%.

DISCUSSION

Results reported in this study are all from tests that relied on natural inoculum and infection for the establishment of disease. Previous studies of soybean diseases (3,5) have utilized either greenhouse or field-grown plants artificially inoculated with individual isolates of the pathogen under study. The present study, therefore, has several basic advantages: a) the disease develops from naturally occurring inoculum; b) this inoculum represents the many strains occurring at that location and is not limited to a single strain selected by the investigator; c) the strains are naturally aggressive, neither attenuated by being maintained in culture nor selected for exceptional virulence; and d) infections occur at a time determined by host susceptibility and pathogen availability, not by administration of arbitrary doses of inoculum to the crops in the field.

The utilization of natural inoculum and infection requires that the investigator manipulate disease severity through some other means—eg, the use of fungicides. Regression analysis can then indicate not only the damage potential of the disease but also the ability to prevent disease and increase yield using available technology. This method does, however, allow the fungicides to affect low-frequency diseases occuring in the field.

The data indicate that severe losses resulted when soybean cultivars were infected with *C. truncatum*. The individual regression equations indicate that some soybean cultivars (Essex) may be more affected by anthracnose than others. Average changes in seed yields projected from quadratic regression curves indicate that losses due to anthracnose typically began to increase rapidly when the severity ratings approached 3.0. At this rating anthracnose was found on pods, and pod infections became progressively more severe as the ratings increased in value. It can be assumed that pod (and seed) damage is the major component of yield loss for soybeans infected with *C. truncatum*. These data do not indicate the typical severity of anthracnose on soybeans grown in the southeastern United States, but rather indicate losses under severe disease conditions. As described in a previous paper (1), disease development in soybeans is environmentally dependent, requiring a prediction system for optimal control.

The scatter of data points in Fig. 1 illustrates the difficulties of performing research under field conditions where development of disease relies on natural inoculum for infection. The typical problems of location within the test, equipment performance, and human error all contribute to data point scatter. However, the use of pesticides to reduce these losses illustrates the yield increases that can be achieved by application of pesticides. The data presented here indicate that *C. truncatum* can cause significant yield losses in soybean fields in the southeastern United States. Losses were particularly high when the pathogen infected the pods.

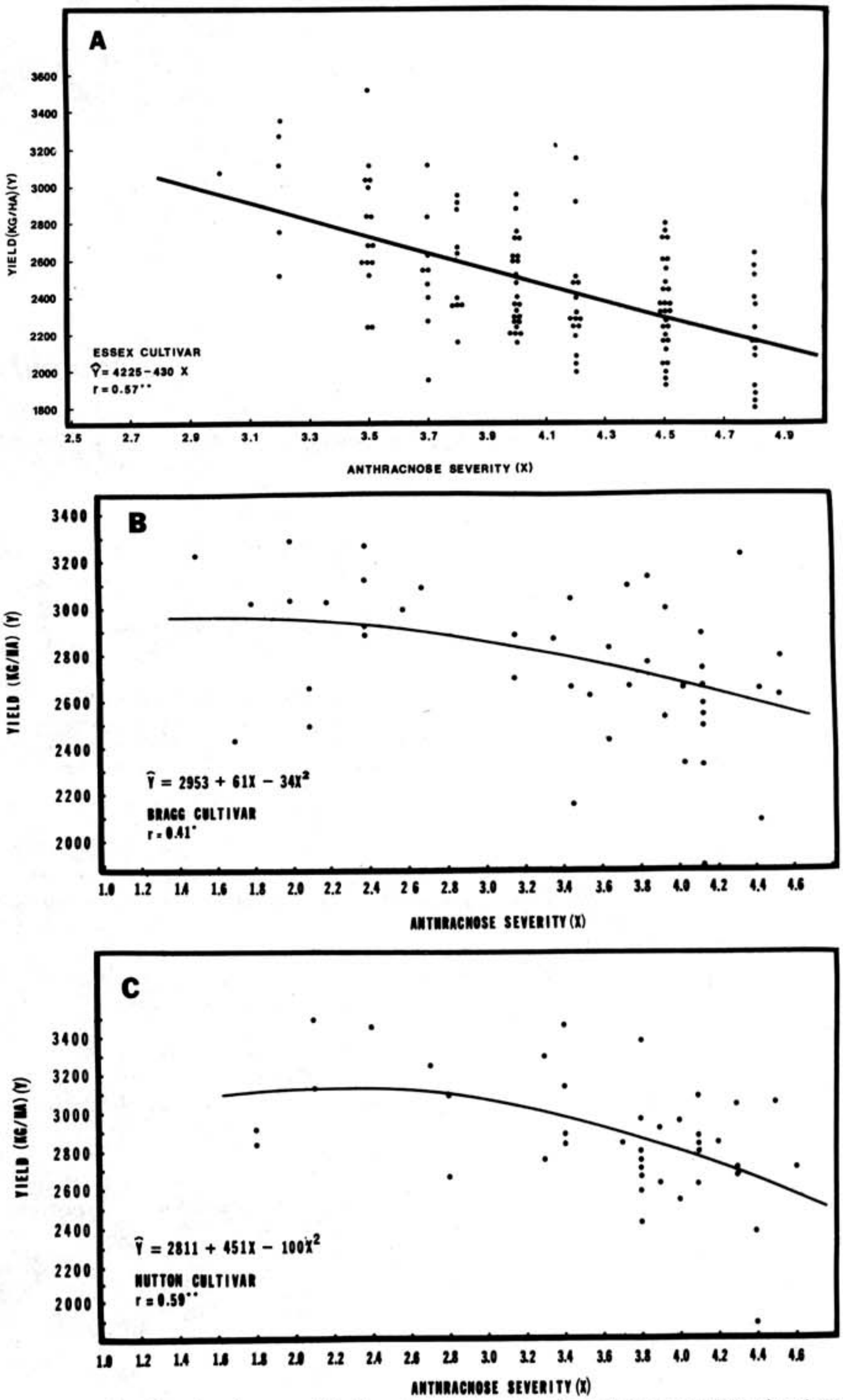

Fig. 1. Relationship of anthracnose (*Colletotrichum truncatum*) severity to seed yield of soybean cultivars **(A)** Essex, **(B)** Bragg, and **(C)** Hutton. *Indicates significance at $P = 0.05$; **indicates significance at $P = 0.01$.

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