Relationship Between Anthracnose Leaf Blight and Losses in Grain Yield of Sorghum

M. E. K. ALI, Graduate Research Assistant, H. L. WARREN, Professor of Plant Pathology and Research Plant Pathologist, ARS, USDA, and R. X. LATIN, Assistant Professor, Department of Botany and Plant Pathology, Purdue University, West Lafayette, IN 47907

ABSTRACT

Ali, M. E. K., Warren, H. L., and Latin, R. X. 1987. Relationship between anthracnose leaf blight and losses in grain yield of sorghum. Plant Disease 71:803-806.

In a 2-yr field study, the relationship between anthracnose leaf blight (ALB) severity index and losses in grain yield of three sorghum lines inoculated with nine isolates of *Colletotrichum graminicola* was determined. Highly significant ($P < 0.01$) positive correlations between percent loss in grain yield and ALB severity index occurred in 1984 and 1985 and for the pooled data of both years, with correlation coefficients of 0.86, 0.84, and 0.85, respectively. Correlations between percent loss in 100-seed weight and ALB severity also were highly significant ($P < 0.01$) for the individual and pooled data of both years. The highly significant ($P < 0.01$) positive correlations between percent loss in grain yield and percent loss in 100-seed weight indicate that ALB reduces grain yield of sorghum largely by decreasing seed weight.

Additional key words: *Sorghum bicolor*

Sorghum anthracnose, caused by *Colletotrichum graminicola* (Ces.) Wils., has been reported in most areas where sorghum (*Sorghum bicolor* (L.) Moench) is grown, but it is generally more prevalent and severe in warm, humid regions of the world (2,12–15).

Sorghum anthracnose may limit grain sorghum production in the humid southeastern United States (6,7), Latin America, Brazil, Venezuela (11), and other humid tropical and subtropical areas (2,13). Losses in grain yield were estimated to exceed 50% on susceptible cultivars in a severe anthracnose epiphytotic (6). Grain yield also has been reported to be reduced by as much as 70% because of incomplete grain fill as shown by a decrease in seed weight and seed density (13). Gorbet (4) reported that grain production of susceptible sorghums is severely limited when the disease develops during heading or early grain filling. Correlation coefficients between anthracnose severity and grain yield in 42 sorghum hybrids were negative and highly significant for all disease rating dates; however, r^2 values decreased as grain developed from the milk stage to harvest (5). The percent loss in sorghum grain yield varied from 1.2 to 16.4 depending on anthracnose severity (9). Serious yield losses may not result from anthracnose leaf blight (ALB) if symptoms appear after plants mature (8).

The purpose of this study was to determine whether significant grain yield losses would result from artificially induced epiphytotics of ALB caused by nine isolates of *C. graminicola* with varying levels of virulence and aggressiveness on four sorghum lines and to establish if there was any relationship between ALB severity and loss in grain yield.

Cooperative investigations of the ARS, USDA, and the Purdue University Experiment Station. Journal Paper 10883 of the Purdue University Agricultural Experiment Station, West Lafayette, IN 47907.

Accepted for publication 10 April 1987 (submitted for electronic processing).

MATERIALS AND METHODS

Nine sorghum isolates of *C. graminicola* obtained from Indiana, Georgia, Florida, and Puerto Rico were cultured from single conidia and maintained on oatmeal agar under constant, cool-white fluorescent light (3,600 lux) at 23 ± 1 C (2). Individual effects of these nine isolates of *C. graminicola* on grain yield of sorghum were studied on four sorghum lines (IS4225, 954130, IS8361, and 954206) from the Purdue Sorghum Collection. Sorghum lines IS4225 and IS8361 are susceptible to all nine isolates, 954130 is susceptible to three isolates, and 954206 is resistant to all nine isolates (1). Because sorghum line 954206 showed the same hypersensitive reaction to all isolates, data from that line were not included in the yield loss analyses.

The study was conducted in 1984 and 1985 at the Purdue Agronomy Farm. The sorghum lines were planted in a split-plot arrangement of a randomized complete block design with three replicates. Isolates were randomized as whole plots, and the sorghum lines were randomized as subplots. Isolate treatments were separated by four rows of the resistant sorghum line Br64 to prevent interplot contamination. Each sorghum line was

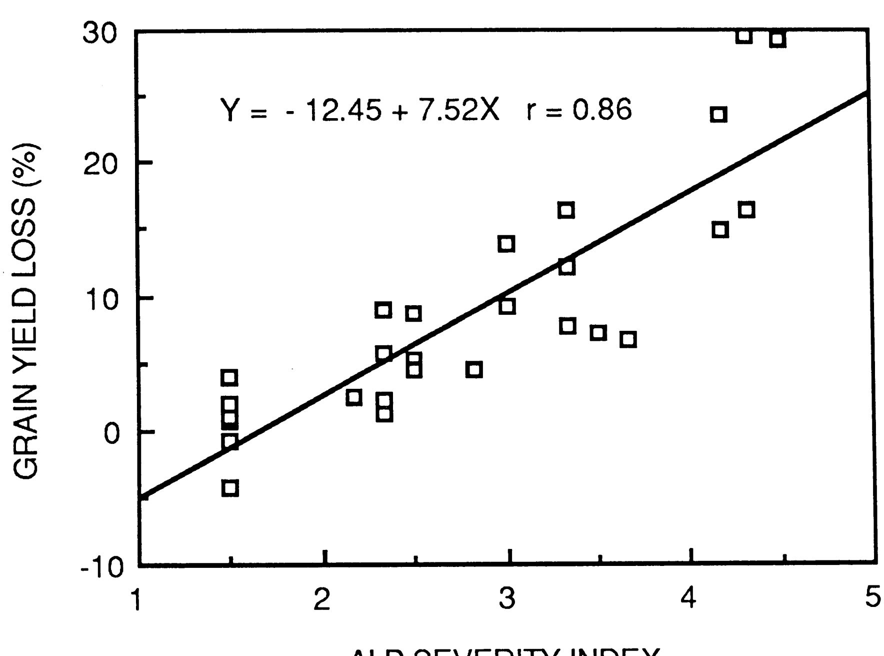

Fig. 1. Relationship between percent loss of grain yield and anthracnose leaf blight severity in 1984. Data points are the mean percentages of yield losses of three sorghum lines inoculated with nine isolates of *Colletotrichum graminicola* at the whorl stage.

planted in two rows 0.75 m apart and 5.1 m long, with plants spaced 10 cm apart. One control treatment consisted of spraying each sorghum line three times at 2-wk-intervals with mancozeb (Dithane M-45) at 1.5 lb/acre to maintain disease-free controls. Fungicide spraying started at the time of the first inoculation. Another control consisted of plants sprayed only with water to detect interplot contamination and external inoculum. Control plots were part of the split-plot arrangement of the randomized complete block design with three replicates.

Inoculum was prepared from 7-day-old cultures grown on oatmeal agar under constant light. The method of inoculum preparation was the same as that reported by Ferreira and Warren (3). One drop of Tween 80 (polyoxyethylene sorbitan monolaurate) per 100 ml of conidial suspension was added as a wetting agent. About 5 ml of conidial suspension was applied into the plant whorl (final leaf visible in whorl) with a pressurized sprayer. All plants in the two rows of each sorghum line were inoculated. Inoculations were done late in the afternoon to minimize rapid drying of inoculum by high temperatures and to ensure good infection. In 1984, plants were inoculated 64 and 71 days after planting (late whorl stage) with inoculum concentrations adjusted to 1×10^6 and 2×10^6 conidia per milliliter, respectively. The sorghum lines were evaluated for reaction type and severity of ALB at 23, 37, and 51 days after inoculation. In 1985, plants were inoculated 56 and 64 days after planting (midwhorl stage), with inoculum concentrations adjusted to 4×10^5 and 6×10^6 conidia per milliliter, respectively. In 1984, lesions coalesced before they expanded, and in 1985, lower inoculum concentrations were used at an earlier growth stage. Sorghum lines were evaluated for reaction type and severity of ALB 25, 38, and 51 days after the first inoculation. ALB severity was estimated with a scale of 1–5 (3).

To avoid border effects, plants 0.75 m from both ends of each row were not harvested. A row of 3.6 m was harvested for grain yield and 100-seed weight determinations. Grain was harvested manually, and the heads were dried for 2 wk before threshing.

Grain yield and 100-seed weight for each sorghum line were determined. To determine whether the reduction in grain yield was associated with the decrease in seed weight, correlation coefficient and regression of percent loss in grain yield on percent loss in 100-seed weight was computed for each year. Yield data (treatment means) were expressed as percent yield loss, which was calculated as follows: yield of water-sprayed control − yield of treated plants/yield of water-sprayed control × 100. The susceptibility of the three sorghum lines (IS4225, IS8361, and 954130) to the different isolates of *C. graminicola* varied considerably each year, and therefore, a range of infection levels was observed. Consequently, the data from these three sorghum lines in each year were pooled to test the relationship between percent loss in grain yield or 100-seed weight and the severity of ALB recorded at maturity. Regression analysis was performed to test these relationships using the Minitab Statistical Package (Pennsylvania State University, University Park). Correlation coefficients between percent loss in grain yield or percent loss in 100-seed weight and ALB severity also were computed as an evaluation of the effect of the disease on these yield parameters. Regression lines describing the disease-yield loss relationship for each year were tested for similarity using a general linear test method (10).

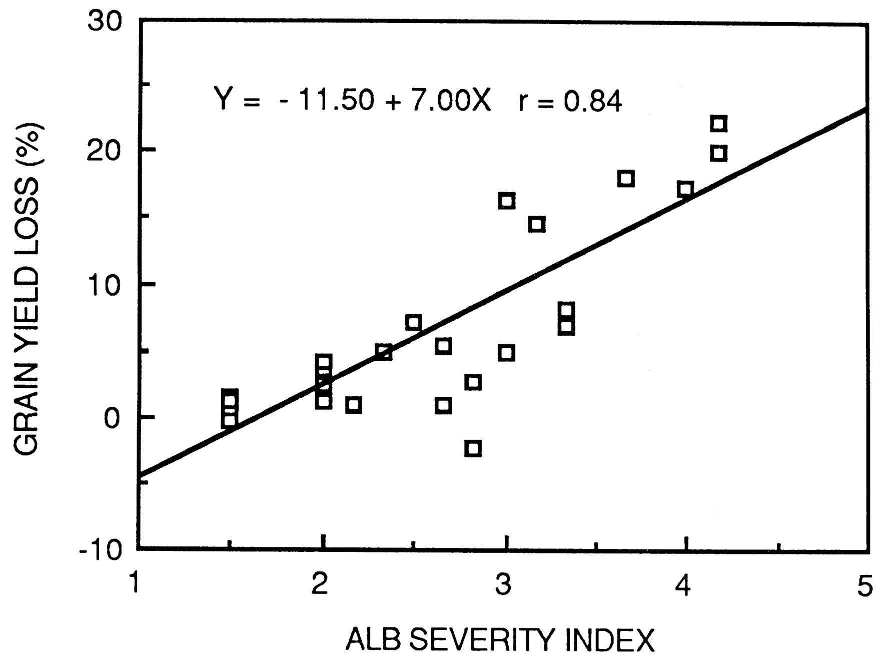

Fig. 2. Relationship between percent loss of grain yield and anthracnose leaf blight severity in 1985. Data points are the mean percentages of yield losses of three sorghum lines inoculated with nine isolates of *Colletotrichum graminicola* at the whorl stage.

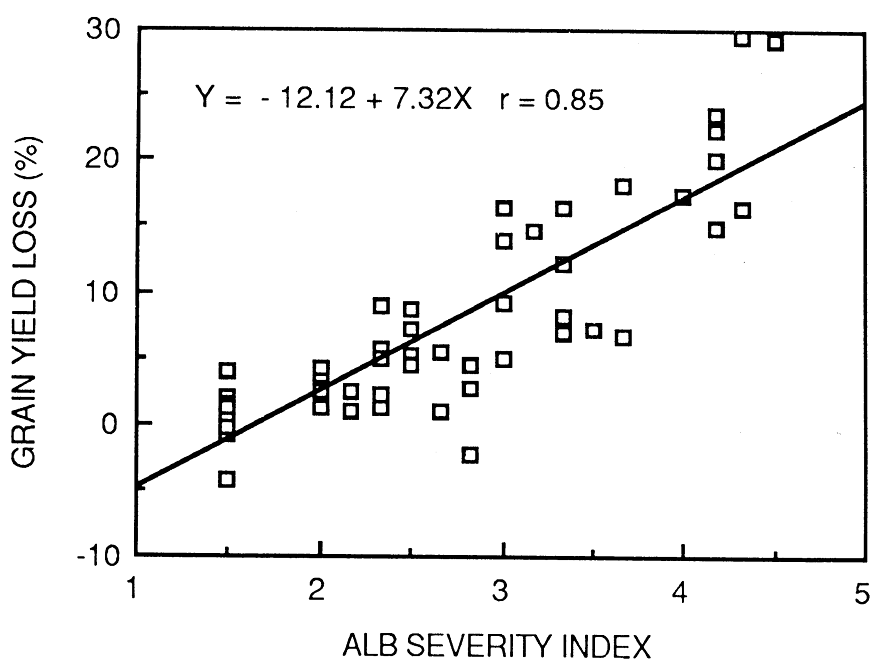

Fig. 3. Relationship between percent loss of grain yield and anthracnose leaf blight severity for the pooled data of 1984 and 1985.

RESULTS

In 1984 and 1985, neither anthracnose nor other serious foliar diseases were present in the water-sprayed or fungicide-treated plots. This indicated that there was no interference from either external inoculum or interplot contamination. Because no other serious diseases were present, reduction in yield was mainly attributable to ALB.

Isolates of *C. graminicola* varied considerably in their aggressiveness on susceptible sorghum lines so that varying degrees of loss in grain yield were obtained for the different isolates. Considerable variation in the percent loss in grain yield was observed among equally susceptible sorghum lines (Figs. 1–3).

Effects on grain yield. Correlation coefficients and regression of percent loss in grain yield on ALB severity computed for the three sorghum lines showed there were highly significant ($P < 0.01$) positive correlations between percent loss in grain yield and ALB severity in 1984 (Fig. 1) and 1985 (Fig. 2), with correlation coefficients of 0.86 and 0.84, respectively. Because the regression lines describing the disease-yield loss relationship for each year were not significantly different, the data were pooled and a single disease-yield loss equation was determined. This resulted in a highly significant ($P < 0.01$) positive correlation between percent loss in grain yield and ALB severity, with a correlation coefficient of 0.85 (Fig. 3). For the pooled data of both years, each unit increase in ALB severity index resulted in a loss of 7.32% in grain yield.

In 1984 and 1985, the highest actual loss in grain yield was about 30 and 22%, respectively.

Effects on 100-seed weight. Highly significant ($P < 0.01$) positive correlations between percent loss in 100-seed weight and ALB severity index occurred in 1984 and 1985, with correlation coefficients of 0.80 and 0.73, respectively. The data from both years were pooled because the relationship between percent loss in 100-seed weight and ALB severity was similar for 1984 and 1985. The correlation coefficient for the pooled data is 0.77 (Fig. 4). A loss of 2.72% in 100-seed weight was associated with each unit increase in ALB severity index.

In 1984 and 1985, the highest actual reduction in 100-seed weight was about 13 and 10%, respectively. Highly significant ($P < 0.01$) positive correlations between percent loss in grain yield and percent loss in 100-seed weight occurred in 1984 and 1985, with correlation coefficients of 0.95 and 0.79, respectively. The data from both years were pooled because the relationship between percent loss in grain yield and percent loss in 100-seed weight was similar for individual years. The correlation coefficient for the pooled data is 0.88 (Fig. 5).

DISCUSSION

Losses as great as 30% in grain yield of the susceptible sorghum cultivar IS8361 occurred when plants were inoculated with an aggressive isolate (3230) of *C. graminicola* at the whorl stage. Under field conditions, three isolates designated as race 2 (3230 from Georgia and CG-1A and CG-1C from Puerto Rico) were more aggressive than the other isolates on sorghum cultivars IS4225 and IS8361 (1).

The evidence presented in this paper shows a significant linear relationship between ALB severity and percent loss in grain yield. The highly significant ($P < 0.01$) positive correlations between loss in grain yield and ALB severity for the individual and pooled data of 1984 and 1985 support previous reports (4–7,13) that anthracnose could result in significant reductions in grain yields of susceptible sorghum cultivars.

Although the regression lines describing the disease-yield loss relationship for 1984 and 1985 were not significantly different, the percent loss in grain yield or 100-seed weight was comparatively higher for 1984 than for 1985 as indicated by a steeper slope in 1984. This was probably due to differential anthracnose development as influenced by the environment each year.

Points reflecting yield or seed weight gains (i.e., negative loss) generally represent data from sorghum line 954130, which is resistant to some of the isolates (Figs. 1–4).

Highly significant ($P < 0.01$) positive correlations between percent loss in grain yield and percent loss in 100-seed weight

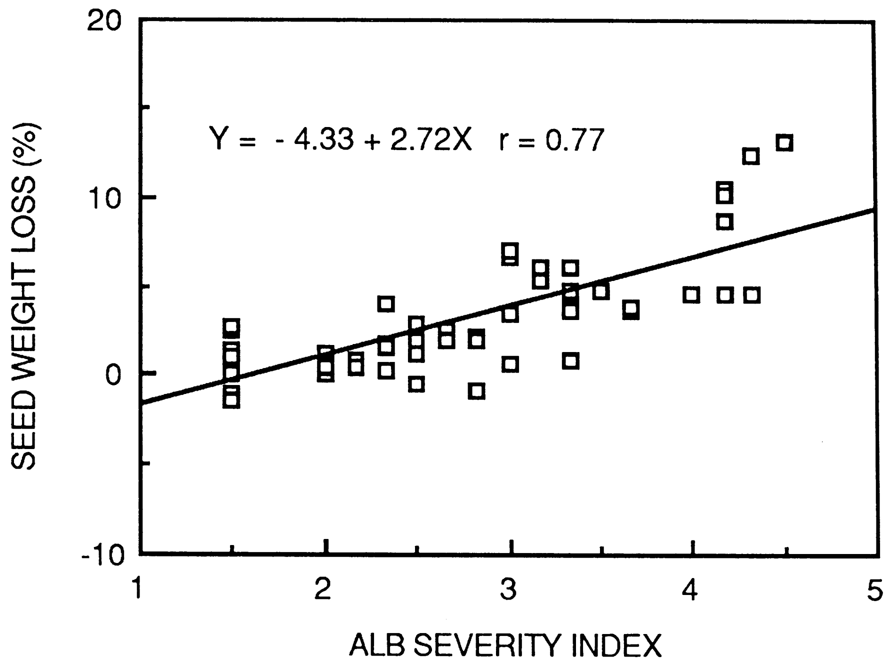

Fig. 4. Relationship between percent loss in 100-seed weight and anthracnose leaf blight severity for the pooled data of 1984 and 1985. Data points are the mean percentages of losses in 100-seed weight of three sorghum lines inoculated with nine isolates of *Colletotrichum graminicola* at the whorl stage.

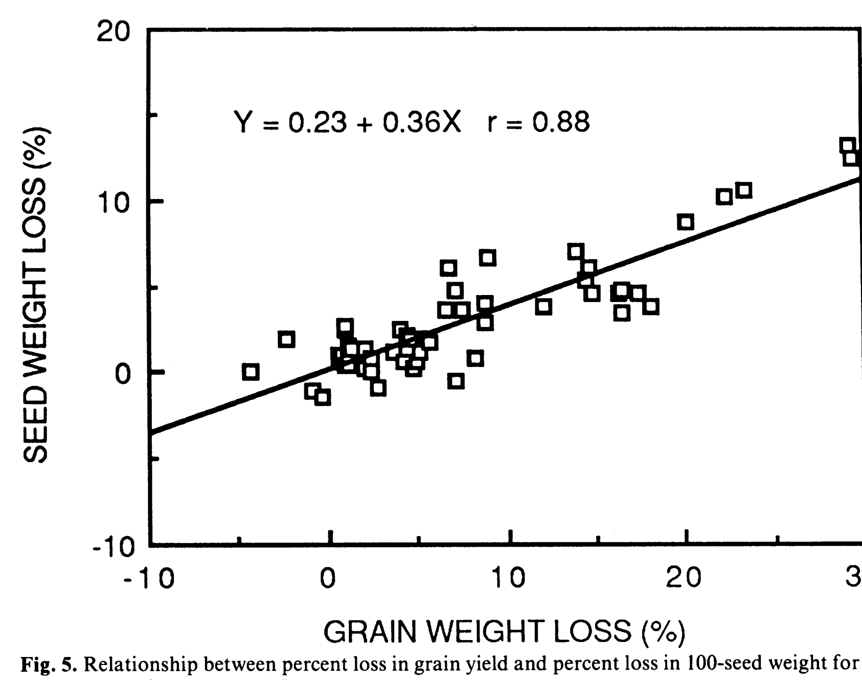

Fig. 5. Relationship between percent loss in grain yield and percent loss in 100-seed weight for the pooled data of 1984 and 1985.

occurred in the individual and pooled data of 1984 and 1985, with r^2 values of 0.90, 0.63, and 0.78, respectively. This indicates that the decrease in 100-seed weight explained 90, 63, and 78% of the total loss in grain yield in 1984 and 1985 and the pooled data of both years, respectively. This agrees with the report attributing the reduction in grain yield to incomplete grain fill (13) as verified by a decrease in seed weight and seed density.

Our results suggest that the amount of loss in grain yield attributable to ALB is influenced by the aggressiveness of the pathogen, sorghum genotype, and environmental conditions that affect anthracnose development. Consequently, any yield loss study should consider pathogen variability, genotypes of the host, and the environmental conditions under which the crop is grown.

The significant linear relationship established in this study between ALB severity and loss in grain yield may be important in determining the economic threshold level of the disease so that justifiable control measures would be adopted.

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