An Epidemic Record of Endemic Alternaria Blight of Spurred Anoda

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ABSTRACT

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Alternaria blight (*Alternaria macrospora*) of spurred anoda (*Anoda cristata*) is endemic in the Mississippi Delta area. An epidemic of the disease was observed in a 33-ha field of soybean (*Glycine max*) in Arkansas in 1992. The soybean field was heavily infested with spurred anoda with densities varying from less than five to 27 stems per square meter. In 2 wk, the disease developed from a few foci observed in early August throughout the field. Field maps of soybean stand, weed density, and disease levels were made. Defoliation varied from 30 to 100%, depending on distance and direction from disease foci in middle August. Disease gradients were determined by examining infections on leaves or stems at 3-m intervals from a focus to 180 m away. The infection gradient was shallow for leaf but steep for stem infections. A high incidence of rust (*Puccinia heterospora*) on spurred anoda was also observed in the field. Spurred anoda plants over the entire field were killed by the end of August (soybean growth stage R4). The control of this weed by natural infection of an endemic disease over such a large area was associated with cool and rainy weather.

Additional keywords: biological control

Spurred anoda (*Anoda cristata* (L.) Schlechtend.) is an important weed problem in much of the soybean (*Glycine max* (L.) Merr.) and cotton (*Gossypium hirsutum* L.) production areas of the southern United States. The weed can produce many secondary stems and compete with crops for space and nutrition. Alternaria blight of spurred anoda, caused by *Alternaria macrospora* A. Zimmerm. (Fig. 1), was first described in 1977 (7) and is endemic in the Mississippi Delta region. The pathogen has been studied as a potential mycoherbicide to control spurred anoda (12,13).

Vanderplank categorized plant diseases as endemic or epidemic. An endemic disease occurs at a low level on a small scale, while an epidemic disease can occur at a high level and on a large scale (11). Pathogens used as mycoherbicides are often considered to be endemic (10). Understanding the factors that maintain the endemic nature of the pathogens studied may help in manipulating epidemics of these endemic pathogens for biological control of weeds (9). However, very few epidemic records of endemic pathogens exist, especially those related to biological control. The objective of this study was to document a sporadic outbreak of the endemic Alternaria blight of spurred anoda, which resulted in natural biological control of the weed over a large area.

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MATERIALS AND METHODS

Location. The epidemic occurred in the summer of 1992 in a 33-ha soybean field located 16 km from the Mississippi River in Hughes, Arkansas. The field, bordered by woods on the eastern and southern sides, had been planted with soybean in 1991 and was flooded in the early spring of 1992. The field was planted with soybean at a 75-cm row spacing in an east-west orientation. Although the preplant herbicide glyphosate (Roundup) was applied, a heavy infestation of spurred anoda remained in the field. Between-row cultivation during the soybean seedling stage was also used to control weeds. A high number of spurred anoda remained in the rows after cultivation. These plants resulted in very high weed density (Fig. 2). Alternaria blight on spurred anoda was first observed by growers in late July.

Disease. *A. macrospora* was identified from samples of diseased plants. Observations of the disease development began in August. Efforts were made to document the causal agent and the general spatial feature of the disease over the entire field. Disease foci were identified by the degree of plant infections, because plants in the foci expressed severe and uniform damage both on leaves and stems. We also attempted to quantitatively describe the spatial aspect of the epidemic. Notes on the occurrence of the disease on adjacent fields located on the eastern and western sides were also taken.

Mapping. To quantitatively describe the spatial features of the epidemic, maps were made on 19 August 1992 to illustrate the association of crop stand, weed density, defoliation, and stem infection for a large portion (300 × 740 m) of the field heavily infested with the weed. This area was first divided into quadrates of 20 × 20 m. Each quadrate was further divided into four subquadrates of 10 × 10 m. In each subquadrate, the number of spurred anoda stems was counted from a section of 1 × 0.75 m selected to represent the average density of the subquadrate. Defoliation (percentage of leaf area infected) and stem infection (proportion of dead stem tissues) was estimated for each subquadrate. The soybean stand, which also reflected the vigor of the plants, was recorded on a scale of 1–4, where 1 = nearly no soybean, 2 = poor, 3 = good, 4 = very good. At the center of each quadrate, weed density and disease were measured so that there were five data points per quadrate. The mean of each quadrate was calculated from five samples for weed density and disease. Rating of the field was completed in four and a half days. Maps were made for crop stand, weed density, and disease severity (the mean of defoliation and stem infections). Each variable was divided into different levels (Fig. 3) and plotted using the GMAP procedure in the SAS Graphics package.

Disease gradient. Disease gradients were measured in a north-south direction. From the center of a disease focus located at the middle of the northern side of the field, defoliation and stem infections were measured at 3-m intervals in three parallel 1-m sections. Stem infections were measured separately on northern and southern sides of the stems. Disease means at each interval were calculated from the three sections and plotted against the distance to determine the disease gradient. In the north of the focus, only observations were made and disease gradient was not measured, because very few spurred anoda plants were available.

RESULTS

Soybean and weed. Soybean growth was relatively poor in this field, especially on the eastern side where there was a large area, about 80 × 200 m, with very few soybeans (Fig. 3A). In the middle of the north border of the field, there was another area with very few soybean plants. The areas where soybean stands were poor were heavily infested by spurred anoda with the highest density, 27 stems per square meter. There was such an area near the middle of the north side of the field (Fig. 3B). On the western side, soybeans grew relatively well and weed densities were relatively low, generally ranging from five to 15 stems per square meter.

Disease. In early August, individual disease foci where severe infections occurred were readily distinguished from each other on the west side and near the middle of the north edge of the field. Disease severity decreased as the distance from the center of a focus increased (Fig. 4A). In the central area of a focus, spurred anoda plants were killed due to severe stem and leaf infections. Entire stems turned brown and were dry (Fig. 4B). In the area around a focus, plants were uniformly defoliated with only part of the stem being infected (Fig. 4C). However, no severe infections were observed on plants on the eastern side of the field (Fig. 2).

In the middle of August when disease was mapped, the disease was still less severe on the eastern side of the field (Fig. 3C). Leaf infections accounted for the disease severity ratings in that area because stem infections were low (0–5%). There were three large disease foci in the west half of the field, as indicated by the darkest spots in the map (Fig. 3C): at middle of the north edge, near the northwest, and near the southwest (see Fig. 4A). There was also a small focus in the southwest part of the field, which was only partially mapped. The largest focus, in the middle of the north edge, had an area of about 2,400 m^2 (Fig. 3C). No major disease focus was found in the eastern side of the field.

Rust (*Puccinia heterospora* Berk. & M.A. Curtis) (Fig. 4D) was also observed on both leaves and stems of spurred anoda plants throughout the field. Although rust was found on every plant, its impact on disease severity was not clear. Severe Alternaria blight prevented flowering of spurred anoda, which generally starts in early August. On 31 August 1993, we found that spurred anoda plants in the entire field were killed, while spurred anoda plants in the adjacent field were not severely damaged, although they were infected by rust.

Disease gradient. In the north-south direction, the disease gradient on leaves was very flat from the disease focus on the north edge (Fig. 5). Disease severity on leaves was greater than 60% at 180 m from the focus. However, the infection of stems decreased exponentially as distance increased. Stem infections occurred equally on both sides of the stem when plants were near the focus, but the difference in infections between northern and southern sides of stems increased as the distance increased. At 60 m from the focus, stem infections were 30 and 15% for northern and southern sides of stems, respectively. No infection was found on the southern side of stems more than 140 m from the initial point. North of the focus, although there were very few spurred anoda plants, infections were higher on the southern side of the stems than on the northern side.

DISCUSSION

Alternaria blight of spurred anoda is an endemic disease in the Mississippi Delta. The first and only documented epidemic of this disease occurred in 1974 (7), but no detailed data were recorded. This is the first report of a large-scale epidemic of this disease with detailed data on disease severity, weed density, and spatial information. This report as well as others (1,3,7,8) showed that endemic pathogens can cause epidemics. Epidemiologically, it is important to determine when and how an endemic disease becomes epidemic to advance our understanding of the stability of plant pathosystems (14). However, some important information was missing in our study, because we were unable to document the onset of the epidemic which was observed by growers in July. The foci mapped here reflect a picture in the middle of the epidemic process. Earlier observations may have allowed us to describe the initial formation of disease foci.

This epidemic apparently was associated with three factors. The first factor was the high density of spurred anoda plants in this field. In some areas of the field, the weeds were uniformly growing at densities of more than 25 stems per square meter. High weed densities with uniform distribution would positively affect disease epidemics (9). The second factor was the unusually rainy and cool summer weather in 1992. The temperature during the 1992 summer in Arkansas was the coolest in the past 100 years (2). Weather records (6) at Marianna (30 km from Hughes) showed that mean temperatures for July and August were 25.5 and 23 C, respectively. There were 17 recorded days with rainfall between July 16 and August 15. Temperatures of 20–25 C with 24-hr dew periods have been reported to be optimal for the infection of spurred anoda by *A. macrospora* (4,12). The third factor may be the co-occurrence of rust (*P. heterospora*) on spurred anoda. Occurrence of rust was also reported in the previous epidemic (7). Crawley et al (5) reported that spurred anoda plants older than the fourth-leaf stage were not damaged as severely as younger plants, and inoculation of *A. macrospora* 5 days after the inoculation with *Fusarium lateritium* Nees:Fr. resulted in higher mortality than when either pathogen was used alone. However, it was difficult to quantify the effects of rust on an infection of *A. macrospora* in our study because rapid development of Alternaria blight symptoms made the assessment of rust severity difficult. Observation of rust on spurred anoda in adjacent fields, however, indicated that rust alone did not result in plant mortality. Available

Fig. 1. A spurred anoda leaf infected by *Alternaria macrospora.*

Fig. 2. Area of the soybean field infested with spurred anoda.

information (5,7), as well as this study, implies that *A. macrospora* may be exacerbated when another disease is present on spurred anoda.

This study provides evidence of weed control over a large area by a naturally occurring epidemic. Although this endemic pathogen has been studied as a mycoherbicide, this particular epidemic demonstrated natural weed control. In this field, the control effect in some areas was similar to the control when a pathogen is used as a mycoherbicide, in which the weeds were infected uniformly and killed rapidly. This indicates that this pathogen has attributes for both the classical and mycoherbicide approaches (10).

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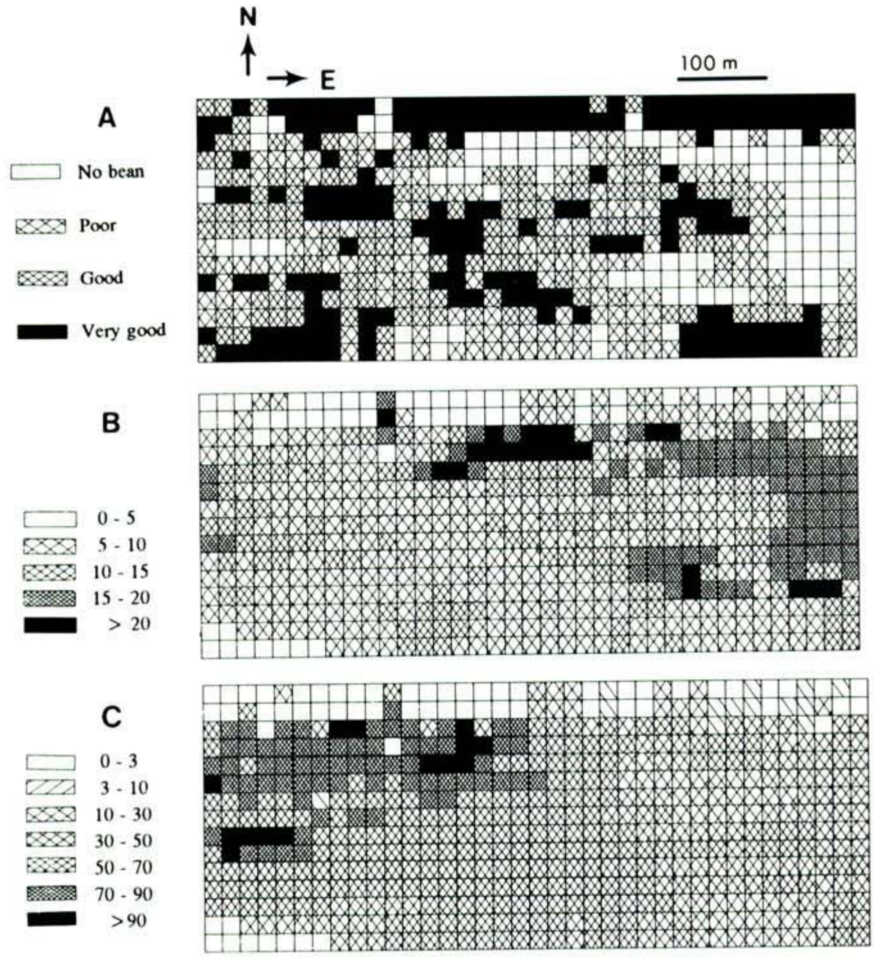

Fig. 3. Maps of Alternaria blight (*Alternaria macrospora*) on spurred anoda in a 33-ha soybean field in 1992 in Arkansas: **(A)** soybean stand (also refers to plant vigor), **(B)** density of spurred anoda (stems/m^2), and **(C)** severity of Alternaria blight on spurred anoda (mean of leaf and stem infection).

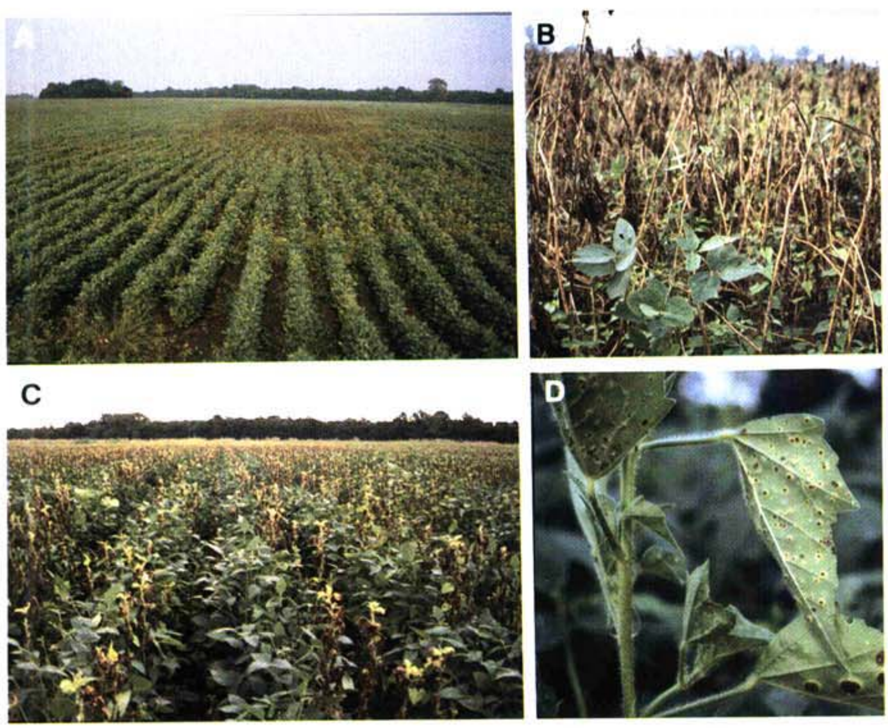

Fig. 4. The epidemic of Alternaria blight (*Alternaria macrospora*) of spurred anoda in a 33-ha soybean field (taken on 14 August 1992): **(A)** a focus of Alternaria blight of spurred anoda in which the disease gradient can be seen, **(B)** spurred anoda plants in a disease focus, **(C)** area distant from foci where there were uniform and severe foliar infections but stems were less infected, and **(D)** rust (*Puccinia heterospora*) on spurred anoda.

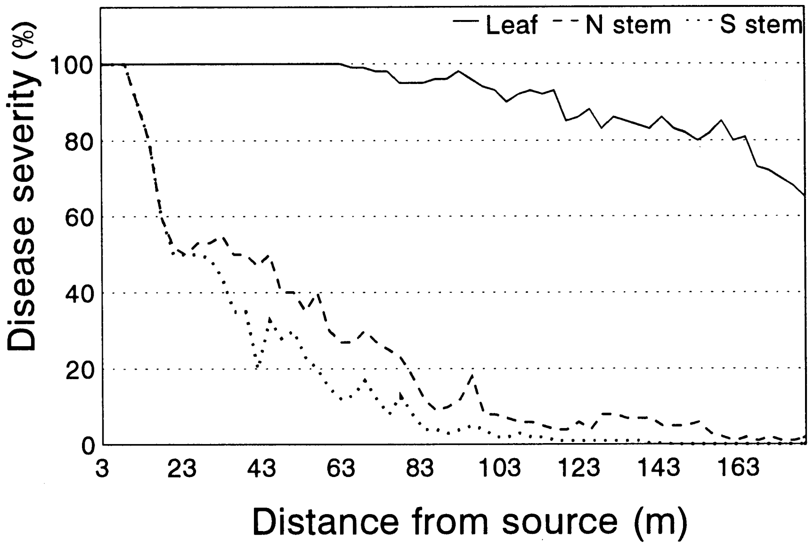

Fig. 5. Gradients of Alternaria blight (*Alternaria macrospora*) of spurred anoda from a disease focus in north-south direction. Gradients for stem infections were measured for northern (N) and southern (S) sides of stems, respectively.

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