Puccinia polysora Epidemics on Maize Associated with Cropping Practice and Genetic Homogeneity

M. C. Futrell

Research Plant Pathologist, Plant Science Laboratory, Agricultural Research Service, U.S. Department of Agriculture, and the Mississippi Agricultural and Forestry Experiment Station, Mississippi State 39762.

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ABSTRACT

Southern corn rust (which is incited by *Puccinia polysora*) caused losses to late-planted corn in the lower Mississippi River valley in 1972, 1973, and 1974. The northern limit of the epiphytotics was Natchez, Mississippi, in 1972; Cairo, Illinois, in 1973; and southern Illinois and Indiana in 1974. The 1974 epiphytotic extended eastward from the Mississippi River into the Tennessee, Cumberland, and Ohio River valleys. This epiphytotic reached western Kentucky by late June and probably would have spread into the main part of the Corn Belt except for dry weather in June and July. Yields of heavily rusted late-planted corn were 5,320 kg/hectare (ha), compared with 9,604 kg/ha for nonrusted early planted corn. Severe stalk lodging was associated with heavy rust infection. Two major factors are believed to contribute to increased rust incidence on corn in the lower Mississippi River valley: (i) late-season corn production has increased with attempts to grow two corn crops annually, and (ii) limited germplasm in currently grown hybrids has reduced genetic diversity leaving corn genetically vulnerable to *P. polysora*.

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Southern corn rust which is caused by *Puccinia polysora* Underw. was identified in Alabama in 1891 on *Tripiacum dactyloides* L. (13). Since then it has been regarded as a minor pathogen of corn, *Zea mays* L. This disease was found in the Corn Belt in 1949 (12) and 1958 (5), and in North Carolina in 1972 and 1973 (7).

The increased demand in the southern United States for corn to feed poultry, dairy cows, and swine has changed production practices in the lower Mississippi River valley. Corn growers have attempted to grow two crops of corn per year. The first crop is planted in February and harvested in June. The second is planted in late June and harvested in October.

This paper reports increased incidence of this disease on corn in the lower Mississippi River valley in 1972, 1973, and 1974 and relates the outbreak to cropping practices and genetic vulnerability.

MATERIALS AND METHODS.—Data on the distribution of *P. polysora* in the lower Mississippi River valley were collected from commercial corn fields and experimental plots in 1972, 1973, and 1974. During the summer of 1974, when it became obvious that *P. polysora* was going to become epiphytotic in western Kentucky, corn fields with different planting dates (20 April, 8 May, 20 May, and 25 June) were selected in an area 3 miles east of Lake Barkley in Trigg County, Kentucky. Comparative disease severity and response readings were recorded for corn in these fields on 30 August 1974. Yields were taken by harvesting four random 5-m row samples from rows growing 96 cm apart and converting data to kg/ha. All fields were of the same commercial hybrid and received the same fertilization treatments. Stalk lodging was also recorded by counting four samples of 100 stalks per sample. Yields and stalk lodging data, recorded 25 October 1974, were analyzed by Duncan's (2) new multiple range test.

RESULTS.—There was a build-up of southern corn rust in the lower Mississippi valley over the 1972-1974 period (Fig. 1). The northern limit of rust spread in 1972 was Natchez, Mississippi. In August 1973, rust was found over a wider area including Mississippi, part of Louisiana, east Texas, western Alabama, extreme eastern Arkansas, western Tennessee, western Kentucky, and the southern tip of Illinois. The occurrence and northward spread of *P. polysora* in 1974 was much earlier than in previous years. The source of primary inoculum has not been determined; it may have blown in from the Caribbean. The rust was found in Jackson County, on the Gulf Coast in southeastern Mississippi, in March 1974. By mid-April, rust was found in corn fields as far north as Natchez. In late May and early June corn fields in the Memphis area showed rust infections, and by late June to mid-July fields in western Tennessee and Kentucky were infected by uredospore showers. Dry weather probably prevented establishment of the rust in Missouri and in the Corn Belt. The pattern of spread prior to the dry weather was similar to that of southern corn leaf blight that reached northwestern Kentucky by 15 July 1970 (8). The rust spread eastward in the Tennessee, Cumberland, and Ohio River valleys during August and September (Fig. 1). The most severe damage occurred in valleys adjacent to Kentucky Lake on the Tennessee River and Barkley Lake on the Cumberland River.

Rust developed in corn fields planted 20 May and 25 June near Lake Barkley (Table 1). The most severe development of rust (rated 80 S) was on corn planted 25 June. All plants in late-planted fields were infected. Yields in heavily rusted (which had been plated 20 June) corn were 5,320 kg/hectare (ha) compared with 9,604 kg/ha on nonrusted, earlier-planted corn. Severe stalk lodging occurred in corn with heavy rust infection, presumably because *P. polysora* drastically reduced stalk strength.

DISCUSSION.—Some yield reduction recorded in Table 1 was due to differences in planting date. A 20-year running experiment in Ohio showed that corn planted 7 May and 21 May had a difference in yield of 439 kg/ha (11). The difference in my study in yield of corn planted 8 May and 20 May was 2,483 kg/ha with only 10% of the leaf area covered with susceptible-type pustules, which demonstrates the destructive potential of this rust pathogen.

Harlan (4) has warned that the line between abundance and disaster is small, and that the public is not aware and is unconcerned about food production. He further stated that the genetic base of all our major food crops has been narrowed. Corn lines B37, W64A, and Oh43 comprise

25.7, 13, and 11.7%, respectively, of the seed corn production requirements for the United States in 1970 (9). Thus, three inbred lines made up approximately 50% of the seed corn production requirements in the United States, and all three inbreds are susceptible to *P. polysora*. Many other inbred lines currently used in the United States' corn production also are susceptible to this rust.

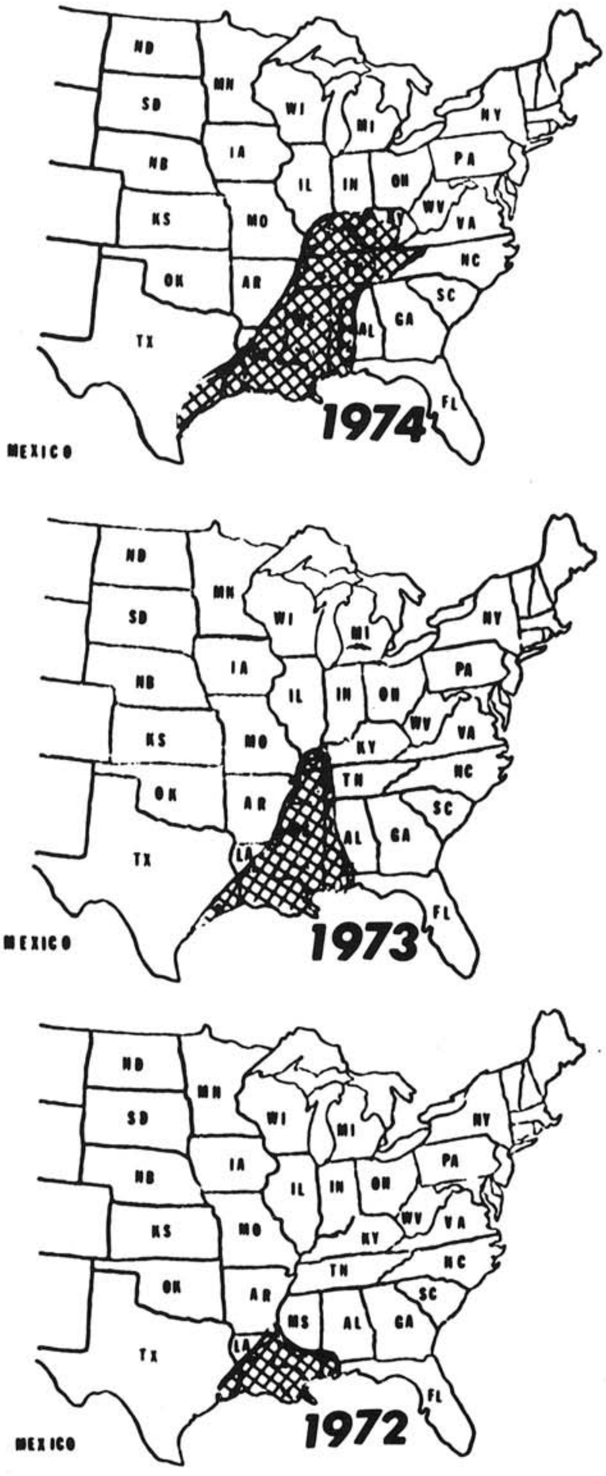

Fig. 1. Three-year distribution pattern of *Puccinia polysora* on corn in the Mississippi River valley. Cross-hatched areas indicate distribution of southern corn rust in successive years.

The genetic base of many crops has been narrowed in breeding for high yield. A narrowed genetic base provides a genetic environment for the destructive increase of new races of plant pathogens (9). The increased prevalence of destructive races of plant pathogens quickly reduces yield. High yields are essential for maintaining world food supply. Harlan (4) pointed out that world population dictates that there is no returning to low yields. The destructive epiphytotic of corn rust incited by *P. polysora* in Nigeria in the 1950's brought reductions in yield and famine, and van der Plank (14) stated that there was an increase in frequency of genes for rust-resistance in native Nigerian open-pollinated corns. I was a member of a team that worked on the improvement of major cereal crops in Africa in the 1960's. The Nigerian Department of Agriculture and the U.S. Agency for International Development made an all out effort to develop corn inbreds with resistance to *P. polysora*. Two of these lines, PR-Mp 1 and PR-Mp4 have been released (M. C. Futrell, *unpublished*) in the United States. The frequency of genes for rust resistance was very low in the material from which these lines were developed.

The widespread use of restricted germplasm has lead to disastrous epidemics of plant pathogens on wheat and corn in the United States. Dickson (1) pointed out how the widespread use of wheat cultivar Ceres led to the increase of race 56 of *Puccinia graminis tritici* Erick. and E. Henn. and the devastating epiphytotic of 1936. History repeated itself with the wide use of Hope that enabled race 15b of the wheat stem rust fungus to become epiphytotic in 1952-1954. The wide use of Texas cytoplasmic male-sterile corn in breeding programs terminated with the southern corn leaf blight epiphytotic of 1970. According to the National Academy of Science report (9) fifteen percent of the corn in the United States was destroyed by this disease. This was the greatest monetary loss caused by a plant disease in one crop in one year in the history of agriculture in the United States.

The quick shift by the seed corn industry from Texas male-sterile to normal cytoplasm corn in the southern United States in 1971 prevented the build-up of southern corn leaf blight in that area. Prevention of inoculum production within geographic areas, as described by Futrell and Atkins (3) and Knott (6), has effectively controlled both stem rust of wheat and blight of corn. It should be put into practice for control of *P. polysora* on corn. The lower Mississippi River valley is the critical area for *P. polysora* build-up. The shift to resistant hybrids should be made as rapidly as possible in that area. The seed corn industry needs corn inbreds with rust resistance combined with high yield and good agronomic quality to make this shift. Monogenic resistance alone should be used only as a last resort as a stop-gap measure because widespread use of single resistance genes gives new virulent races an opportunity to increase. Nine physiologic races of *P. polysora* were described by Robert (10).

The growing of two crops of corn annually in the lower Mississippi River valley has contributed to the increase of

TABLE 1. The effect of late planting date and rust infection on yield and stalk lodging of a commercial corn hybrid growing near Lake Barkley in western Kentucky in 1974

Planting date	Rust reading[a]	Yields (kg/ha)[b]	Stalk lodging[b] (%)
20 April	0	9,604 A	0
8 May	0	8,475 B	0
20 May	10 S	5,992 C	8 A
25 June	80 S	5,320 D	63 B

[a]The numbers indicate the percentage of the leaf area covered, and the (S) indicates a susceptible-type rust pustule.

[b]Data are means of four samples. Means followed by the same letter in a line did not differ significantly according to Duncan's new multiple range test, $P = 0.05$.

southern corn rust. The early maturing hybrids used by farmers in this area are of Corn Belt origin. The quick-maturing hybrids are used in order to make two annual crops possible. I have screened all hybrids currently being used in the two-crop system, and all are susceptible to *P. polysora*.

A mass screening program of corn germplasm to find new sources of resistance to *P. polysora* is now being conducted in Mississippi. Corn inbreds and early-generation breeding material have been received from many corn breeding programs in the Corn Belt, the southern United States, Nigeria, Mexico, Puerto Rico, and other Latin American countries. The resistance found is being incorporated into highly productive agronomic types of inbreds and hybrids.

Corn hybrids made up of an inbred line containing monogenic resistance combined with lines containing polygenic resistance will be tested during the second corn-growing season in 1975 in southern Mississippi. The U.S. Department of Agriculture and the Mississippi Agricultural and Forestry Experiment Station plan for resistant hybrids to be in production at the earliest possible date, hopefully before an epiphytotic of *P. polysora* occurs in the southern United States and produces overwhelming inoculum blowing northward into the Corn Belt.

LITERATURE CITED

1. DICKSON, J. G. 1956. Diseases of field crops. McGraw-Hill Book Co., Inc. New York. 517 p.
2. DUNCAN, D. B. 1955. Multiple-range and multiple-F tests. Biometrics 11:1-42.
3. FUTRELL, M. C., and I. M. ATKINS. 1957. Trends in diseases in cereal crops in Texas in recent years. Plant Dis. Rep. 41:42-46.
4. HARLAN, J. R. 1972. Genetics of disaster. J. Environ. Qual. 1:212-215.
5. HOOKER, A. L. 1961. Occurrence of Puccinia polysora in Illinois. Plant Dis. Rep. 45:236.
6. KNOTT, D. R. 1972. Using race specific resistance to manage evolution of plant pathogens. J. Environ. Qual. 1:227-231.
7. LEONARD, K. J. 1974. Foliar pathogens of corn in North Carolina. Plant Dis. Rep. 58:532-535.
8. MOORE, W. F. 1970. Origin and spread of southern corn leaf blight in 1970. Plant Dis. Rep. 54:1104-1108.
9. NATIONAL ACADEMY OF SCIENCES. 1972. Genetic vulnerability of major crops. Washington, D.C. 307 p.
10. ROBERT, A. L. 1962. Host ranges and races of the corn rusts. Phytopathology 52:1010-1012.
11. STRINGFIELD, G. H. 1955. Corn culture. Pages 343-378 *in* George F. Sprague, (ed.) Corn and corn improvement. Academic Press, New York. 699 p.
12. ULLSTRUP, A. J. 1950. Corn diseases in Indiana in 1949. Plant Dis. Rep. 34:89-99.
13. UNDERWOOD, L. M. 1897. Some new fungi chiefly from Alabama. Bull. Torrey Bot. Club 24:81-86.
14. VAN DER PLANK, J. E. 1968. Diseases resistance in plants. Academic Press, New York. 206 p.