PHYSIOLOGIC SPECIALIZATION IN *DRECHSLERA TERES*

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Summary

The occurrence of physiologic specialization in *D. teres* is reported. Three distinct physiologic races could be differentiated on two barley varieties, Algerian (C.I. 1179) and C.I. 7584. The distribution of these physiologic races in Western Australia is shown.

Sources of resistance to the above races have been identified and classed according to the degree of resistance. The majority of resistant varieties originated from Ethiopia and Manchuria, with those from Ethiopia providing a higher degree of resistance. The pathogenicity of the local isolates is discussed in relation to reports from other places.

I. INTRODUCTION

Drechslera teres (Sacc.) Shoem., the causal agent of net blotch, is a serious pathogen of barley.

Considerable work has been done in the search for suitable sources of resistance. The initial contemporary study was conducted by Schaller and Wiebe (1952), who tested the U.S.D.A. barley collection under field conditions in California. Later, Singh (1956) in Minnesota and Frecha (1958) in Argentina retested certain of the resistant varieties identified by Schaller and Wiebe (1952), reporting that their results did not fully substantiate the earlier report. Neither were the results obtained by Singh (1956) fully corroborated by Frecha (1958). The divergence of the reports is indicative of the possible existence of physiologic specialization, although until the present studies there does not appear to have been any systematic attempt to identify physiologic races. At the 40th annual meeting of the American Phytopathological Society, Pon (1949) reported that isolates of *D. teres* differed sharply in their pathogenicity on certain barley varieties. In the results of Singh (1956), obtained from studies of the damaged leaf area of barley varieties, there is an evidence of physiologic specialization. In a brief note, McDonald and Buchannon (1962) recognized two physiologic races in Canada. More recently, Gray (1966) has shown a difference in the virulence between Canadian and Californian isolates.

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Since 1952, the U.S.D.A. barley collection has been tested in Canada by Buchannon and McDonald (1965) and in Egypt by Dessouki, Mansour, and Khalifa (1965). Evidence for pathogenic variability has been presented in both these studies. Similar evidence has been reported by Kenneth *et al.* (1967) in Israel, and by Khan, Boyd, and Shipton (1968) in Western Australia.

The purpose of this paper is to report on the existence of physiologic specialization among isolates of *D. teres* collected in Western Australia, and to comment on the sources of resistance in the large range of imported and local barley varieties tested.

II. Materials and Methods

Of the 142 barley varieties used in this study, 138 were selected because of their resistant or differential reactions in reported studies,* and four are the varieties commercially grown in Western Australia.

The 17 monoconidial isolates used in this study are presented in Table 1. The isolates were subcultured on V-8 Juice agar and maintained at 15°C, under continuous fluorescent illumination.

Table 1

ISOLATES OF *D. TERES* FROM WESTERN AUSTRALIA USED IN THIS STUDY

Isolate Accession Number	Locality of Collection	Isolate Accession Number	Locality of Collection	Isolate Accession Number	Locality of Collection
177	Kellerberrin	299	Williams	353	Toodyay
210	Kendenup	302	Katanning	355	Merredin
218	Chapman	348	Perth	356	Mullewa
260	Esperance	350	Gibson	357	Northampton
274	Southern Cross	351	Narrogin	358	Mullewa
278	Merredin	352	Ongerup		

Ten plants of each variety were grown in 5-in. pots in air-conditioned glasshouse rooms. Throughout the experimental period, programmed temperatures ranged from 18°C minimum to 24°C maximum. Seedlings, 15 days old, were sprayed with a conidial suspension standardized at 10,000 conidia per millilitre. Plants were then maintained at 95–100% R.H. for 48 hr under reduced light conditions ($5 \cdot 38$–$10 \cdot 76 \times 10^4$ lux). Thereafter, plants were replaced on glasshouse benches where they received an average of 12 hr of natural daylight. Infection was scored 2 weeks later using a five-class scale; 0, no observable infection; 1, pin-point lesions without chlorosis; 2, slightly developed dark brown lesions with no chlorosis; 3, restricted longitudinal brown streaks with slight chlorosis of the adjacent areas; 4, brown elongated lesions, criss-crossed with dark-coloured net-like venation, surrounded by marked chlorotic areas. Mesothetic-type reactions were also observed. They are indicated as X(2,3) etc., where different types of reactions observed in this class are written in parentheses in order of abundance.

As it was not possible to screen simultaneously the reaction of the varieties to all isolates, initially only isolates 177 and 260 were used. This decision was based on previous indications that

* The seeds were obtained from Dr. J. Craddock, U.S.D.A., Beltsville, Maryland, U.S.A., and from Dr. K. W. Buchannon, Canada Department of Agriculture Research Station, Winnipeg, Canada.

these isolates were pathogenically different. The results confirmed the suggested difference in virulence. The number of varieties tested was then reduced from 142 to 75, and, of these, 70 exhibited resistance to at least one of the isolates; the other five were commercial varieties. These 75 varieties were then tested to the remaining races and a third pathogenically different race was discovered. The experiments were repeated several times to confirm the findings.

All the varieties were also grown at Narrogin, Mullewa, and Esperance, W.A., to record field reaction.

III. Results

Four varieties were found to exhibit clear-cut differential reactions on inoculation with isolates 177, 260, and 299. Of these, the reaction spectra of C.I. 7584, C.I. 2235, and C.I. 9776 were identical, and these differed from that obtained on Algerian (C.I. 1179). This combination permits the identification of four possible physiologic races (Table 2). Only three were found to occur in Western Australia. These were tentatively named W.A.-1, W.A.-2, and W.A.-3, and the isolates representing each were classified accordingly.

Table 2

FOUR RACES IDENTIFIABLE USING TWO DIFFERENTIAL VARIETIES

Race	Reactions* to the Differential Variety:		Isolates Conforming to Different Races
	Algerian (C.I. 1179)	C.I. 7584, C.I. 2235, C.I. 9776	
W.A.-1	R	R	299, 348, 351, 352, 355, 356, 357
W.A.-2	S	R	177, 210, 218, 274, 278, 302, 353, 358
W.A.-3	R	S	260, 350
W.A.-4	S	S	Not yet identified in Western Australia

* R = resistant (1- or 2-type reaction—see Section II); S = susceptible (4-type reaction).

On the basis of the reactions to isolates 299, 177, and 260, representing races W.A.-1, W.A.-2, and W.A.-3 respectively, five classes of varieties were recognized (Table 3):

(1) Highly resistant—those varieties which exhibited 1-type reaction to all the races under glasshouse conditions and in the field.
(2) Resistant—those exhibiting 1- and 2-type or only 2-type reactions to all the races under both glasshouse and field conditions.
(3) Field resistant—those which exhibited variable reaction under conditions prevailing in glasshouse tests, but which were resistant to the same races in the field.
(4) Differentials—those exhibiting clear-cut differential reactions.
(5) Susceptible—those showing 4-type reactions to all the races under all conditions of testing.

Varieties exhibiting variable reaction in both glasshouse and field studies have not been included in this classification.

TABLE 3

REACTION OF BARLEY VARIETIES CLASSIFIED AS HIGHLY RESISTANT, RESISTANT, FIELD RESISTANT, DIFFERENTIAL, AND SUSCEPTIBLE TO RACES W.A.-1, W.A.-2, AND W.A.-3 OF *D. TERES*

Reactions scored as described in Section II

Variety	C.I. No.	Origin	Reaction to *D. teres* of Race: W.A.-1 (Isolate 299)	W.A.-2 (Isolate 177)	W.A.-3 (Isolate 260)	Field Reaction*
			Class 1—Highly Resistant			
—	1615	China	1	1	1	R
—	5791	Ethiopia	1	1	1	R
—	9819	Ethiopia	1	1	1	R
—	9820	Ethiopia	1	1	1	R
—	9825	Ethiopia	1	1	1	R
—	9214	Korea	1	1	1	R
—	2750	Manchuria	1	1	1	R
—	4544	Manchuria	1	1	1	R
—	4788	Manchuria	1	1	1	R
—	4794	Manchuria	1	1	1	R
—	4976	Morocco	1	1	1	R
—	5108	U.S.A.	1	1	1	R
			Class 2—Resistant			
—	1243	Abyssinia	2	2	2	R
—	5809	Ethiopia	1	1	2	R
—	5822	Ethiopia	1	X(1,2)	2	R
—	5845	Ethiopia	1	X(1,2)	2	R
—	9547	Ethiopia	2	2	2	R
—	9584	Ethiopia	2	2	2	R
—	9648	Ethiopia	2	X(1,2)	2	R
—	9669	Ethiopia	2	1	1	R
—	9693	Ethiopia	2	1	2	R
—	9768	Ethiopia	1	2	2	R
Hispont	8828	Germany	X(1,2)	1	1	R
—	1698	Hybrid	1	1	X(1,2)	R
Tifang	4407–1	Manchuria	1	1	X(1,2)	R
—	4439	Manchuria	X(1,2)	X(1,2)	1	R
—	4534	Manchuria	1	1	2	R
—	4535	Manchuria	1	1	2	R
—	4795	Manchuria	1	X(1,2)	1	R
Ming	4797	Manchuria	1	1	X(1,2)	R
—	4798	Manchuria	1	1	X(1,2)	R
—	6475	Poland	1	1	2	R
—	5401	U.S.A.	1	X(1,2)	1	R
—	4638	U.S.S.R.	1	1	2	R

TABLE 3 (*Continued*)

Variety	C.I. No.	Origin	Reaction to *D. teres* of Race: W.A.-1 (Isolate 299)	W.A.-2 (Isolate 177)	W.A.-3 (Isolate 260)	Field Reaction*
			Class 3—Field Resistant			
O.A.C. 21	1470	Canada	X(3,4)	X(1,2,3)	X(2,3)	R
Manchuria†	2330	China–Manchuria	X(1,2)	X(2,3)	X(1,2)	R
—	8333	France	2	2	X(2,3)	R
Husky	9537	Hybrid	1	X(1,2,3)	1	R
—	9440	Korea	1	1	X(2,3)	R
—	1175	Manchuria	1	X(2,3)	X(2,3)	R
—	4389	Manchuria	X(1,2)	X(1,2,3)	1	R
—	4410	Manchuria	1	X(2,3)	1	R
—	4539	Manchuria	1	X(2,3)	X(2,3)	R
—	4572	Manchuria	3	1	1	R
—	4793	Manchuria	X(2,3)	1	X(1,2)	R
—	4918	Manchuria	1	X(1,2)	X(1,2,3)	R
Harbin†	4929	Manchuria	1	X(2,3)	X(2,3)	R
—	3430	Switzerland	2	X(2,3)	2	R
			Class 4—Differential			
Algerian	1179	Algeria	1	4	1	—
—	9776	Morocco	1	1	4	—
—	2235	Unknown	1	1	4	—
—	7584	U.S.A.	1	1	4	—
			Class 5—Susceptible			
Atlas	4118	—	4	4	4	S(xxx)
Beecher	—	—	4	4	4	S(xxx)
Bussel	13520	—	4	4	4	S(xx)
Dampier	13521	—	4	4	4	S(xx)
Hazera 212	—	—	4	4	4	S(x)
Prior	—	—	4	4	4	S(xxx)

* Field reaction recorded at Mullewa, Narrogin, and Esperance. R = resistant; S = susceptible. Severity of infection in case of susceptible reaction is indicated in parentheses as follows: x = slight; xx = moderate; xxx = severe.

† Required high pre-inoculation temperature to exhibit uniform resistance.

IV. DISCUSSION

It is believed that this is the first published account of physiologic specialization in *D. teres*, although in his thesis work Gray (1966) reported the occurrence of two physiologic races in North America.

In Western Australia, three physiologic races were found to occur. They can be differentiated on two barley varieties, C.I. 7584 (origin: U.S.A.) and Algerian (C.I. 1179) (origin: Algeria). Varieties C.I. 2235 and C.I. 9776 may be substituted for C.I. 7584. No race has yet been isolated which is virulent on both the differential varieties.

Schaller and Wiebe (1952), from California, reported Manchurian varieties to be the main sources of resistance to net blotch. Later, Buchannon and McDonald (1965) found that the majority of varieties resistant to Canadian races originated from Ethiopia. We found resistant varieties of both Manchurian and Ethiopian origin and that the Ethiopian varieties generally exhibited a higher degree of resistance. Of the 12 varieties which were classed as highly resistant, four came from Manchuria, four from Ethiopia, and one each from China, Korea, Morocco, and U.S.A. Twenty-two varieties were classed as resistant; of these, nine originated from Ethiopia and seven from Manchuria. The majority of the varieties which exhibited variable reactions under glasshouse conditions, but proved resistant in the field, originated from Manchuria.

Kenneth (1962) has indicated Middle Eastern Region as the centre of origin of *D. teres*. The high degree of resistance of Ethiopian varieties, therefore, seems to have evolved as a selective factor in the presence of highly variable populations of the pathogen in those areas.

Hazera 212, a commercial net-blotch-resistant variety in Israel, which has Harbin (C.I. 4929) as its resistant parent, proved susceptible to every Western Australian isolate to which it was tested. Harbin has also been reported to be resistant in California (Schaller and Wiebe 1952) and proved moderately resistant in the present study. The susceptibility of Hazera 212 therefore suggests that Harbin carries genes for resistance to both Western Australian and Israeli races, but in the course of the breeding of Hazera 212 only gene(s) conditioning resistance to Israeli isolates have been selected. This indicates that Western Australian isolates differ from those occurring in Israel.

Varieties such as Manchuria (C.I. 2330) and Harbin (C.I. 4929), which have been reported to show a high degree of resistance in California (Schaller and Wiebe 1952), exhibited variable reactions in the present studies. It was found that these varieties exhibited uniform resistant reaction only when seedlings were treated with pre-inoculation high temperatures. The testings reported by Schaller and Wiebe (1952) were conducted under field conditions in California where barley is grown in summer, in contrast to Western Australian winter growing conditions (Boyd, Khan, and Shearer 1969). The higher degree of resistance of Manchuria and Harbin in California may therefore be due to the higher mean temperatures prevailing during the growing season.

Kenneth *et al.* (1967) found that the instability of *D. teres* cultures rendered it difficult to obtain consistent reaction on the differential host varieties. In our experiments, such variability was associated with the host genotype. The inoculation technique we used enabled us to detect and discard the varieties with inconsistent reactions. The differential varieties identified under such conditions gave consistent reactions in repeated testings with the same isolate.

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