

Seedling Resistance in *Hordeum* to Barley Stripe Rust from Texas

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ABSTRACT

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Stripe rust of barley was recently found in Texas, and the pathogen has been reported to be virulent to U.S. barley cultivars. The stripe rust isolate collected in Texas was used to evaluate the resistance of barley cultivars, germ plasm, and other *Hordeum* species. Limited sources of resistance were found; most were from two of the five primary barley-growing areas. The resistance traces to Czechoslovakia and Ethiopia land cultivars and to the cultivar Derr Winter of unknown origin. The U.S. cultivars with seedling resistance were Barsoy, Betzes, Boxer, Clayton, Compana, Custer, Hazen, Hudson, Kamiak, Kenate, Keowee, Maury, Norbert, and Vanguard. These cultivars represent a range of types that could be a starting point in breeding for resistance. No resistance was found in the economically valuable six-row spring malting type of the north central states. The two most common wild barleys of the Great Plains, *H. jubatum* and *H. pusillum*, were both susceptible to the stripe rust culture used; neither is likely to be a host during the non-crop-growing season.

Stripe rust (yellow rust), caused by *Puccinia striiformis* Westend., has been reported on barley (*Hordeum vulgare* L.) many times. It seldom has been an important pathogen except in Europe, where a form that is particularly virulent on barley occurs (7). This pathogen is known in most of the world as *P. striiformis* f. sp. *hordei*. Stubbs (6) states that stripe rust on barley has not been a major problem in northwestern Europe, even though some susceptible barley cultivars are grown. However, with increasing hectareage of winter barley in Europe, he felt the disease could increase in importance. The European form of barley stripe rust was introduced into Colombia, South America, presumably by air travelers, in 1975. The pathogen then spread southward to

Ecuador, Peru, Bolivia, Chile, and then to Argentina (1,2). Little change in virulence has occurred in barley stripe rust in Europe during the last 50 yr compared to the vast changes that have occurred in wheat stripe rust. Stubbs (6) speculated that under the high disease levels in parts of the Andean region, barley stripe rust would respond with a higher degree of variation, as has occurred in wheat stripe rust. Race 24, limited to Europe prior to 1975, was found in Mexico and then in 1991 in Texas (5). Many European cultivars are resistant to stripe rust but are not adapted to the spring barley-growing regions of the United States. The resistant European barley cultivars are generally of the two-row winter type, whereas in much of the United States, the six-row spring type is preferred (4). Stripe rust of barley has resulted in extensive breeding for resistance in South America and extensive use of fungicides in Mexico.

The appearance of barley stripe rust in Texas (5) warranted the initiation of a study to determine if any of the adapted cultivars in the United States were resistant. Dubin and Stubbs (2) reported that the U.S. cultivars tested in the field in South America were susceptible. The objective of this study was to evaluate

seedlings of selected cultivars from the various U.S. barley production areas and breeding programs, selected germ plasm sources, and selected *Hordeum* spp. for resistance to the Texas stripe rust isolate.

MATERIALS AND METHODS

Cultivars of spring, winter, two-row, and six-row types were selected from each barley-growing region of the United States (Fig. 1). Cultivars from many breeding programs were also included, as were a few cultivars that had been reported resistant elsewhere or that occurred widely in pedigrees. Because of the importance of the barley crop in the Upper Midwest agriculture, cultivars from Minnesota, North Dakota, South Dakota, and Manitoba were emphasized (Table 1). To determine the risk of stripe rust overseasoning on native or introduced weedy species of *Hordeum*, those available accessions of species occurring in the United States were also evaluated (Table 2).

Ten-day-old barley seedlings were inoculated with urediniospores of the original stripe rust culture obtained from Dave Marshall that were collected at Uvalde, Texas, in 1991. Following a 24-hr dew period at 15 C, plants were incubated in a growth chamber at 15 C with a 16-hr photoperiod. Host response was scored 18 and 21 days following inoculation. A second test was done 6 wk later. Wheat and barley lines of known response and barley lines of known resistance were included as checks. Also, a culture of wheat stripe rust was used to check the suitability of environmental conditions during the test. Host response was determined from infection types 0-9 (3). Those cultivars responding with an infection type 4 or less were considered resistant.

RESULTS

The winter barley cultivars Barsoy, Clayton, Hudson, Kamiak, Kenate, Keowee, Maury, and Venus were resis-

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tant to stripe rust (Table 1); however, about 70% of the tested cultivars were susceptible. Spring barley cultivars tested were also generally susceptible, with the exception of Betzes, Boxer, Custer, Hiproly, Norbert, and Vanguard. The resistant malting barley cultivars were Betzes, Compana, Norbert, and Vanguard. Most of the resistant barley cultivars, i.e., Barsoy, Clayton, Kenate, Keowee, Maury, and Venus, were or are grown in the eastern barley area. Resistant six-row cultivars were Barsoy, Clayton, Custer, Hiproly, Hudson, Kamiak, Kenate, Keowee, and Maury, and resistant two-row cultivars were Bearpaw, Betzes, Boxer, and Vanguard.

The pedigrees of the resistant cultivars (infection type 4 or less) were examined to determine the probable source of resistance (Table 3). The widespread resistance in the winter barley cultivars seemed to trace to Michigan Winter (CI 2036). A number of cultivars of European origin were resistant, including Asterix (*Yr1*), Mazurka and Varunda (*Yr2*), I5 (*Yr3*), Cambrinus (*Yr4*), and Emir (*YrAr*) (*data not shown*). Lines

with *Yr5* and *Yr6* (Triumpf) and the other known resistant sources, Hor 1428 and Lada, were not evaluated.

The primary wild barleys of the Great Plains are *H. pusillum* Nuttall in the south and *H. jubatum* L. in the north (Table 2). Both were susceptible to this stripe rust culture, as were the introduced weedy species *H. marinum* Hudson and *H. murinum* L. Resistance is common in other *Hordeum* species worldwide. The wild barley *H. vulgare* L. subsp. *spontaneum* (C. Koch) Thell., which crosses readily with cultivated barley, is a source of varying levels of resistance.

DISCUSSION

Resistance to barley stripe rust is lacking in the malting barley cultivars of the northern Great Plains. In this area, stripe rust probably would not overwinter but could arrive as early spring inoculum from the south. *H. jubatum* is a common weed in this area, but it lacks green tissue during the winter months, making it unlikely to serve as a bridging host during the non-barley-growing season. The greatest number of resistant accessions

were found in the winter six-row feed types that are not grown on a large area. These cultivars likely obtained their resistance from Michigan Winter, which is a selection from Derr Winter, origin unknown. Michigan Winter or its derivatives occur in the pedigrees of Clayton, Hudson, Kamiak, Keowee, and Maury. The second identifiable source of resistance was the two-row spring malting barley cultivars Betzes and Vanguard from the western U.S. barley-growing region. The source of this resistance is uncertain but originated in land cultivars Bethges II and Bethges III from Czechoslovakia. Hiproly is probably a third resistance source and traces to land cultivars in Ethiopia. The resistance found in Barsoy, Boxer, Custer, and Kenate could not be traced because information concerning their parentage was lacking. They may have obtained their resistance from sources similar to those of the foregoing groups or from one or more unique sources.

To control the stripe rust of barley that has appeared in the southern United States, resistance is needed in cultivars

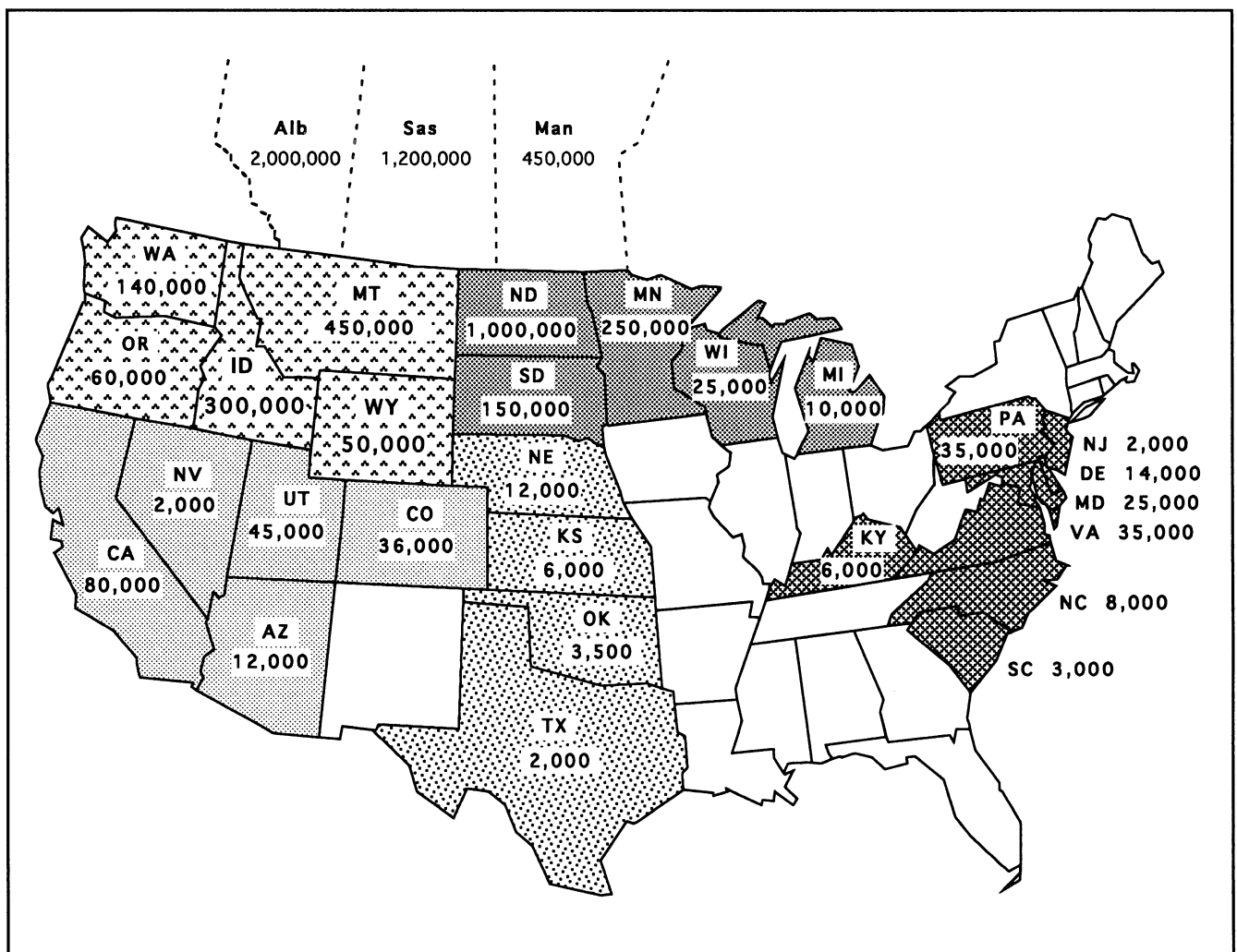


Fig. 1. Areas in hectares of barley in states and provinces producing most of the barley in northern North America: east, six-row winter feed barley; south, six-row winter feed barley; north central, two- and six-row spring barley, mostly malting types; northwest, two- and six-row, mostly spring barley, both feed and malting types; southwest, six-row, mostly fall-planted spring feed barley.

Table 1. Seedling response of selected barley cultivars to barley stripe rust isolated from Texas

Cultivar	Accession number	Habit	Row number	Use	Area grown	Origin	Infection type ^a
Anson	CI 15733	Winter	6	Feed	East	North Carolina	9
Azure	CI 15865	Spring	6	Malt	North central	North Dakota	9
B1602	PI 502965	Spring	6	Malt	North central	Colorado	9
Barsoy	CI 11904	Winter	6	Feed	East	Kentucky	0
Bearpaw	PI 531228	Spring	2	Feed	Northwest	Montana	6
Bedford	CI 15774	Spring	6	Feed	North central	Manitoba	8
Berg	CI 6486	Winter	6	Feed	East	Germany	8
Betzes	CI 6398	Spring	2	Malt	Northwest	Germany	2
Bonanza	CI 14002	Spring	6	Malt	North central	Manitoba	9
Bowman	PI 483237	Spring	2	Feed	North central, northwest	North Dakota	7
Boxer	6	1
Chevron	CI 11526	Spring	6	Germ plasm	...	Switzerland	9
Chopper	PI 525193	Spring	2	Forage	North central	Wisconsin	6
Clayton	CI 13797	Winter	6	Feed	East	North Carolina	0
Columbia	PI 494520	Spring	6	Feed	Northwest	Montana	9
Compana	CI 5438	Spring	2	Malt	Northwest	Montana	4
Custer	CI 8053	Spring	6	Feed	South	Utah	0
Eight-twelve	PI 537437	Winter	...	Feed	Northwest	Idaho	9
Excel	PI 539117	Spring	6	Malt	North central	Minnesota	9
Glenn	CI 17769	Spring	6	Malt	North central	North Dakota	9
Gus	PI 494521	Spring	6	Feed	Northwest	Montana	6
Harrington	...	Spring	2	Malt	Northwest, southwest	Canada	9
Hazen	PI 483238	Spring	6	Feed	North central, northwest	North Dakota	4
Hector	CI 15514	Spring	2	Utility	North central, northwest	Alberta	9
Hesk	CI 15816	Winter	6	Feed	Northwest	Oregon	9
Hiproly	CI 3947	Spring	6	Germ plasm	...	Ethiopia	1
Hitchcock	PI 485594	Winter	6	Feed	South	Nebraska	9
Hudson	CI 8067	Winter	6	Feed	Northeast	New York	4
Hundred	PI 536543	Winter	6	Utility	Northwest	Washington	9
Hypana	CI 11772	Spring	2	Feed	Northwest	Montana	9
Johnston	CI 15850	Spring	6	Feed	Northwest	Manitoba	9
Kamiak	CI 15197	Winter	6	Feed	Northwest	Washington	4
Kanby	PI 539139	Winter	6	Feed	South	Kansas	8
Kenate	CI 9570	Winter	6	Feed	East	Ontario	4
Keowee	CI 11369	Winter	6	Feed	East	South Carolina	2
Kindred	CI 6969	Spring	6	Malt	Northwest	North Dakota	9
Klages	CI 15478	Spring	2	Malt	Northwest	Idaho	9
Kline	PI 491550	Winter	6	Feed	East	Georgia	9
Kombar	CI 15694	Spring	6	Feed	Southwest	California	9
Kombyne	CI 15766	Spring	6	Feed	Southwest	California	9
Larker	CI 10468	Spring	6	Malt	North central	North Dakota	9
Lewis	CI 15856	Spring	2	Malt	Northwest	Montana	9
Lud	...	Spring	2	Feed	Northwest	...	9
Manker	CI 15549	Spring	6	Malt	North central	Minnesota	9
Marconee	CI 8107	Winter	6	Feed	East	South Carolina	9
Maury	CI 15692	Winter	6	Feed	East	Virginia	2
Morex	CI 15773	Spring	6	Malt	North central, west	Minnesota	9
Norbert	PI 452125	Spring	2	Malt	North central	Manitoba	4
Pace	CI 9566	Spring	6	Feed	South	Mississippi	8
Paragon	CI 13649	Spring	6	Malt	North central	Manitoba	9
Perkins	PI 536646	Winter	6	Feed	South	Nebraska	9
Post	CI 15696	Winter	6	Feed	South	Oklahoma	9
Prilar	CI 15241	Spring	6	Malt	North central	South Dakota	9
Robust	PI 476976	Spring	6	Malt	North central	Minnesota	9
Rogers	CI 9174	Winter	6	Feed	South	Oklahoma	9
Scio	CI 15863	Winter	6	Feed	Northwest	Oregon	9
Shabet	CI 13827	Spring	2	Malt	Northwest	Montana	9
Shonkin	PI 538761	Spring	2	Feed	Northwest	Montana	9
Step toe	CI 15229	Spring	6	Feed	Northwest, southwest	Montana	9
Summit	PI 494099	Spring	2	Feed	Southwest	Colorado	9
Surry	CI 15689	Winter	6	Feed	East	Virginia	9
Sussex	PI 471914	Winter	6	Feed	East	Virginia	9
Teton	PI 471913	Spring	6	Feed	Northwest	Colorado	9
Unitan	CI 10421	Spring	6	Feed	Northwest	Montana	9
Vanguard	CI 11868	Spring	2	Malt	Northwest	Washington	1
Venus	PI 512252	Winter	6	Feed	East	Georgia	4
Volbar	CI 15557	Winter	6	Feed	East	Tennessee	9
Wanubet	PI 538760	Spring	2	Feed	Northwest	Montana	8
Weskan	PI 560331	Winter	6	Feed	South	Kansas	9
Wintermalt	CI 15767	Winter	6	Malt	East	New York	9
Wong	CI 6728	Winter	6	Feed	East	New York	9
Wysor	PI 501526	Winter	6	Feed	East	Virginia	9

^a After McNeal et al (3).

Table 2. Seedling response of selected *Hordeum* species to barley stripe rust isolated from Texas

<i>Hordeum</i> sp. ^a	Accession number	Remarks	Infection types ^b
<i>bogdanii</i> Wilensky	PI 269406	Central Asian species	0
<i>capense</i> Thunberg	PI 531780	Southern African species	0
<i>jubatum</i> L.	Several accessions ^c	Northern plains weed	9
<i>lechleri</i> (Stendel) Schenck	PI 531787	South American species	0,9
<i>marinum</i> Hudson	PI 304346	Mediterranean coastal weed	9
<i>murinum</i> L.	PI 203464	Old World weed	9
<i>muticum</i> Presl.	H. 958	Argentine species	0
<i>pusillum</i> Nuttall	Several accessions ^d	Southern plains weed	9
<i>vulgare</i> L. subsp. <i>spontaneum</i> (C. Koch) Thell.	Many accessions ^e	Asian wild barley	0-5

^a Provided by National Seed Germplasm Bank.

^b After McNeal et al (3).

^c Twenty collections from the central and northern Great Plains.

^d Ten collections from the southern Great Plains and southeastern United States.

^e Fifty accessions, most from the Middle East.

Table 3. Cultivars exhibiting infection type 4 or less to the stripe rust culture from Texas

Cultivar	Pedigree	Resistant source	Infection type ^a
Barsoy	Aizu 6/Dayton	Unknown	0
Betzes	Bethges II/Bethges III	Unknown	2
Boxer	Unknown	Unknown	1
Clayton	David/Hudson	Michigan Winter	0
Compana	Composite cross I selection	Unknown	4
Custer	Velvon II*4/Barbless	Unknown	0
Hazen	Glenn/4/Nordic/Dickson/Trophy/3/Azure	Unknown	4
Hiproly	Introduction from Ethiopia	Hiproly	1
Hudson	Michigan Winter/Wong	Michigan Winter	4
Kamiak	Bore/Hudson	Michigan Winter	4
Kenate	Composite cross X selection	Unknown	4
Keowee	Davie/Hudson	Michigan Winter	2
Maury	Harrison/3/Cebada Capa/Wong/2/awnletted Hudson selection	Michigan Winter	2
Norbert	Centennial/Klages	Unknown	4
Vanguard	Betzes/Haisa II/Pirolina	Betzes	1

^a After McNeal et al (3).

grown in areas where stripe rust can occur. In the major barley production areas, most of the widely grown cultivars are susceptible. In the east and northwest, some resistance is present in commercial cultivars. In the west, there is a lack of six-row spring types with malting quality to serve as resistance sources.

Resistance to stripe rust in the seedling stage is generally indicative of the pre-booting response. Seedling resistance is important in control, as most of the disease increase occurs during the mild weather from late fall through spring. Seedling resistance is not always a

predictor of postheading response, and thus some of the cultivars labeled here as resistant may be susceptible after heading. *Astrix* and *Cambrinus* were much more susceptible on the secondary leaves than on the primary leaves.

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