Virulence Spectrum of *Puccinia hordei* in North Africa and the Middle East

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ABSTRACT

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New virulence types of *Puccinia hordei* were detected in various geographic regions of North Africa and the Middle East. Isolates able to overcome many sources of resistance were identified. The *P. hordei* virulence types reported in this paper have not been previously identified. They are important not only because they are virulent on the commonly grown barley cultivars but because they are also virulent on the many barley cultivars containing *Pa* genes used as sources of resistance. The effectiveness of Pa_9 to these virulence types was not complete, but Pa_3 and Pa_7 were very effective against all *P. hordei* isolates tested. The naturally occurring *Ornithogalum* spp. in northern and northwestern Tunisia and Merchouch in Morocco may represent a breeding ground for new physiologic races of the *P. hordei* fungus. Isolates originating from the alternate host were as variable in virulence as those isolated from barleys in the same fields.

Leaf rust of barley has received very little attention in the Middle East and North Africa. In this region, the disease is not considered to be a significant factor in limiting barley production because there have been no large-scale epidemics. Recent changes in cultural practices used to grow barley may directly affect the epidemiology of this disease; thus, severity of *Puccinia hordei* Orth. is becoming obvious to plant breeders and plant pathologists in this part of the Mediterranean. Virulence in leaf rust, its importance, and the variability in host resistance are being studied in many parts of Europe and in the United States (5,8–11). The virulence of isolates of physiologically specialized pathogens, such as the rusts, is neither simple nor easy to describe. As data relating to host-parasite systems accumulate and as new differentials are discovered and used, the description becomes increasingly complex and difficult to interpret (1,2). The objectives of this study were to determine the virulence pool of *P. hordei* in various barley-growing areas in the Middle East and North Africa and the relative effectiveness of the known-resistance *Pa* gene or gene combinations.

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MATERIALS AND METHODS

Thirteen spring barley genotypes (Table 1) possessing different *Pa* genes were inoculated with 59 cultures of *P. hordei* from several sites in North Africa and the Middle East. The *Pa* designation by Clifford (3,4) and the USDA CI number are given after the common name of each genotype used.

P. hordei isolates were sampled at nine sites in five countries over 4 yr. Urediospores from a single uredium were isolated from green leaves of commonly growing *Hordeum vulgare* L. In one instance, monouredial cultures were derived from a single aecium from *Ornithogallum* spp. collected at Beja in northwestern Tunisia. Monouredial cultures were multiplied on the universal susceptible barley cultivar, Moore (CI 7251). Inoculum that could not be used within a few days was vacuum-dried and stored at 4 C according to a technique described by Sharp (8). Inoculation procedures and the assessment of the reaction types have been described (8).

In evaluating virulence in this study, the resistant and intermediate reaction types were both considered to be effective resistance. Isolates of *P. hordei* considered avirulent on the differential cultivars developed resistant or intermediate infection types of 0, 1, or 2. Infection types 3 and 4 were considered susceptible.

RESULTS AND DISCUSSION

Fifty-nine monouredial cultures of *P. hordei* from the Mediterranean area were studied. The virulence patterns of these isolates on differential cultivars of barley are shown in Table 2. Of the 10 isolates obtained from Morocco, all were avirulent on Estate (Pa_3) and Cebada Capa (Pa_7). Other isolates, collectively, were virulent on all other members of the differential cultivars. The aecial stage of *P. hordei* on *Ornithogallum* spp. was often observed at the Merchouch, Morocco, collection site situated close to barley infected with leaf rust. Virulence to Cebada Capa (Pa_7) has been reported from Morocco (6). The most virulent Moroccan isolate found in this work attacked all differential barley cultivars except Estate (Pa_3), Cebada Capa (Pa_7), and Ricardo (Pa_2+).

In Tunisia, some of the more extensive lush barley-growing areas are near Mateur and Beja; 33 isolates of *P. hordei* were collected in these areas. The alternate host, *Ornithogallum* spp., was

Table 1. Differential host genotypes for *Puccinia hordei*

Host cultivar	*Pa* genes	USDA CI number
Estate	Pa_3	CI 34102
Cebada Capa	Pa_7	CI 61933
Hor 2596	Pa_9	CI 12434
Ricardo	Pa_2+	CI 63065
Bolivia	$Pa_2 + Pa_6$	CI 12576
Quinn	$Pa_2 + Pa_5$	CI 10247
Magnif	Pa_5	CI 138068
Peruvian	Pa_2	CI 9359
Sudan	*Pa*	CI 648910
Egypt	Pa_8	CI 648111
Batna	Pa_2+	CI 339112
Gold	Pa_4	CI 114513
Reka	Pa_2+	CI 5051

Table 2. Virulence patterns of 59 isolates of *Puccinia hordei* from North Africa and the Middle East

Collection site	Differential cultivars												
	Estate (Pa_3)	Cebada Capa (Pa_7)	Hor 2596 (Pa_9)	Ricardo (Pa_7+)[a]	Sudan (Pa)	Quinn ($Pa_2 + Pa_5$)	Batna (Pa_2+)	Bolivia ($Pa_2 + Pa_6$)	Peruvian (Pa_2)	Magnif (Pa_5)	Egypt (Pa_8)	Reka (Pa_2+)	Gold (Pa_4)
Morocco													
Rabat	3/3[b]	3/3	3/3	1/3	2/3	0/3	2/3	2/3	0/3	0/3	0/3	1/3	1/3
Merchouch	7/7	7/7	4/7	7/7	6/7	5/7	3/7	3/7	4/7	5/7	2/7	0/7	0/7
Tunisia													
Mateur	17/17	17/17	11/17	11/17	8/17	7/17	3/17	4/17	3/17	4/17	0/17	2/17	1/17
Beja	16/16	16/16	11/16	9/16	2/16	3/16	4/16	1/16	2/16	0/16	3/16	0/16	0/16
Oasis	7/7	7/7	5/7	4/7	3/7	4/7	4/7	3/7	3/7	2/7	2/7	0/7	1/7
Egypt													
Sakha	2/2	2/2	2/2	1/2	0/2	1/2	1/2	2/2	0/2	0/2	0/2	1/2	0/2
Giza	1/1	1/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1
Syria													
Aleppo	2/2	2/2	2/2	2/2	1/2	1/2	2/2	1/2	2/2	0/2	0/2	0/2	0/2
Jordan													
Amman	4/4	4/4	2/4	1/4	1/4	1/4	1/4	1/4	1/4	0/4	0/4	1/4	0/4
Total all sites	59/59	59/59	40/59	36/59	23/59	22/59	20/59	17/59	15/59	11/59	7/59	5/59	3/59

[a] Pa_2+ = resistance genes reported to be Pa_2 plus undetermined genes.
[b] Avirulent isolates/total number of isolates.

abundantly distributed here, often contained aeciospores of *P. hordei*, and the plants were closely associated with leaf rust-infected barley plants. Four isolates of *P. hordei* from *Ornithogallum* spp. at Beja used for inoculating the differential barley cultivars showed various ranges of virulence. The most virulent isolate attacked all the barley cultivars except Estate (Pa_3) and Cebada Capa (Pa_7). Isolates collected from barley at both Beja and Mateur showed similar ranges of virulence. Collections made over a 4-yr period tended to show increased ranges of virulence at the later collection dates.

In southern Tunisia, the microclimate in the Oasis was favorable for leaf rust development. Of the seven isolates of *P. hordei* investigated, virulence ranged from attack of 11 of the 13 barley differentials to only two. As noted for other areas, the most virulent isolate attacked all differential cultivars except Estate (Pa_3) and Cebada Capa (Pa_7). It is believed that leaf rust oversummers in the Oasis on volunteer barley.

Nine isolates of *P. hordei* were collected from Egypt, Syria, and Jordan (Table 2). A range of different virulences were obtained at each site. One isolate from Giza, Egypt, and one isolate from Amman, Jordan, showed the most virulence, attacking all *Pa* genes and gene combinations except Pa_3 and Pa_7. Table 2 shows wide ranges of virulences among the *P. hordei* isolates evaluated in this study, but cultivars containing Pa_3, Pa_7, Pa_9, and Pa_2+ as represented in Ricardo appeared as the best sources of resistance. As noted in earlier work (8,10,11), the Pa_2+ designation apparently involves different resistance genes. In this study, for example, Pa_2+ as represented in Reka was attacked by 54 of 59 isolates, whereas Pa_2+ as represented in Ricardo was attacked by only 23 of the 59 isolates.

In evaluating 1,062 isolates of *P. hordei* collected from both *H. spontaneum* Koch and *Ornithogallum* spp. in Israel, Anikster (1) found virulence to all the barley differential cultivars including those containing the Pa_3 and Pa_7 genes; however, only two of the 1,062 isolates attacked all cultivars including Cebada Capa (Pa_7). Even though virulence may develop for the Pa_7 resistance gene, such cultures may lack genes for fitness and not persist in a population. Barley cultivars Henry and Monroe both contain the Pa_7 gene for resistance to *P. hordei* (9). The barley cultivar Henry has been used extensively in commercial production in the southeastern United States for more than 10 yr and still retains effective resistance.

LITERATURE CITED

1. Anikster, Y. 1984. Parasitic specialization of *Puccinia hordei* in Israel. Phytopathology 74:1061-1064.
2. Browder, L. E. 1971. Pathogenic specialization in cereal rust fungi, especially *Puccinia recondita* f. sp. *tritici*, concepts, methods of study and application. Pages 1-51 in: U.S. Dep. Agric. Tech. Bull. 1432.
3. Browder. L. E., Lynn, F. L., and Eversmeyer, M. G. 1980. Races, pathogenicity, phenotypes and type cultures of plant pathogens. Phytopathology 70:581-583.
4. Clifford, B. C. 1974. The choice of barley genotypes to differentiate races of *Puccinia hordei* Otth. Cereal Rust Bull. 2 (1):5-6.
5. Clifford, B. C. 1977. Monitoring virulence in *Puccinia hordei*: A proposal for the choice of host genotype and survey procedures. Cereal Rust Bull. 5:34-38.
6. Parlevliet J. E. 1981. Presence in Morocco of brown rust, *Puccinia hordei*, with wide range of virulence to barley. Cereal Rust Bull. 9:3-8.
7. Sharp. E. L., and Smith, F. G. 1957. Further study on preservation of *Puccinia* urediospores. Phytopathology 47:423-429.
8. Sharp, E. L., and Reinhold, M. 1982. Sources of genes resistant to *Puccinia hordei* in barley. Plant Dis. 66:1012-1013.
9. Starling, T. M., Camper, H. M., Jr., and Roane, C. W. 1980. Registration of Henry barley. Registration of Monroe barley. Crop Sci. 20:284-285.
10. Tan, B. H. 1977. Evaluating host differentials of *Puccinia hordei*. Cereal Rust Bull. 5:17-23.
11. Walther, U., and Lehmann, C. D. 1980. Resistenz Eegenschaften in Gersten und Weizensortiment Gatersleben 24 Prüfung von Sommer und Wintergersten auf ihr verhalten gegenuber Zwergrost (*Puccinia hordei* Otth.) Kulturpflanze 28:227-228.