Evolution of Physiologic Races and Virulence of *Puccinia striiformis* on Wheat in Syria and Lebanon

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ABSTRACT

Yahyaoui, A. H., Hakim, M. S., El Naimi, M., and Rbeiz, N. 2002. Evolution of physiologic races and virulence of *Puccinia striiformis* on wheat in Syria and Lebanon. Plant Dis. 86:499-504.

Virulence-avirulence phenotypes of *Puccinia striiformis* isolates collected in Lebanon and Syria were determined on seedlings of the wheat-yellow rust differential genotypes. We found 25 and 11 physiologic races over 6 years (1994 to 1999) in Syria and Lebanon, respectively. The composition of physiologic races found in Syria and Lebanon differed greatly between 1994 and 1999. Races identified in 1999, such as 230E150 and 230E134, have wider spectra of virulence on resistant genotypes than races collected in 1994. In Lebanon, three races were found in 1994 compared with six races in 1999. Yellow rust differential genotypes were used in a trap nursery to monitor yellow rust populations under natural conditions. Races identified from cultivars in the trap nursery in Syria and Lebanon, and from land race cultivars in Iraq, were recovered among the races identified from farm fields. Yellow rust samples were collected from Yemen, and none of the races identified from Yemen samples were identical to those in Syria and Lebanon. Virulence frequencies in the yellow rust population on the differential genotypes tested in the trap nurseries were above 70% for some resistance genes. Yellow rust populations in Syria and Lebanon have diverse virulence phenotypes. *P. striiformis* populations appear to be changing over, and this would be an important consideration for wheat breeding programs in the region.

Yellow (stripe) rust, caused by *Puccinia striiformis* West., is an important disease of wheat in countries where wheat cultivars are grown in cool environments (3,6,7). The disease is a major problem for wheat production in the Middle East (15) and has been known as an endemic disease in Central and Western Asia (CWA). The apparent increasing frequency and severity of yellow rust epidemics in recent years (1,2,22) in CWA have resulted from the occurrence of new physiological races that were able to overcome widely utilized sources of resistance in wheat (5,6,14,15). At present, 30 resistance genes are catalogued (17); however, large numbers of these genes are not effective due to the presence of corresponding virulence in the pathogen. Most of the known yellow rust resistance genes are race-specific in nature, and virulence has been identified for several of them. Virulence for *Yr9*, which was widely deployed in bread wheat cultivars such as Seri82, Giza64, and Mexipak, spread rapidly throughout the Middle East

region beginning in Yemen and Ethiopia in the late 1980s (3,23). The wheat cultivar Inquitab, based on *Yr27*, and the wheat accession PBW343, based on the combination of *Yr3* and *Yr9*, are highly vulnerable as they are the most important cultivars of northwestern Pakistan and India, respectively (11). The slow rusting gene, *Yr18*, does not confer enough protection under conditions highly conducive to disease (10). Virulence on *Yr2*, *Yr3*, *Yr6*, and *YrA* predominates in the Mexican highlands (11). Virulence on *Yr17*, which is common in Europe, was detected in 1999 in Southern Australia (23).

Pathogenic changes have been a significant factor in the recurrent *P. striiformis* epidemics in the Middle East. In Syria, yellow rust has been observed annually since 1987 (5), and the disease has spread to all wheat-growing areas (13,14). Under irrigated conditions and in the high rainfall areas in northern Syria, the severity of infection reached up to 80% on susceptible cultivars; estimated yield losses on the cultivar Mexipak were 29% (14). Likewise, yellow rust epidemics in Lebanon resulted in an approximate loss of 30% in national grain production in 1994 (12). This tremendous loss in wheat production associated with the yellow rust epidemic was attributed to the favorable environmental conditions in 1994 and to cultivation of the susceptible bread wheat culti-

vars, such as Seri 82 and Mexipak, over large areas (12).

Detection of yellow rust variation has traditionally relied upon the identification of physiologic races in the pathogen population by inoculating a sample of pathogen isolates on a series of host differential cultivars with known resistance genes, and observing the resulting compatible or incompatible disease phenotype. Seedling resistance is usually race-specific and can be recognized by its characteristic resistance type at all plant growth stages (11). Resistant cultivars are deployed against populations of pathogens rather than a particular race (16); hence, the use of specific resistance genes to yellow rust has revealed *P. striiformis* populations that are highly diverse. Despite their limitations, studies of physiologic races in cereal rusts have been tremendously valuable in the development and deployment of host resistance and have provided important insight into the evolution of yellow rust disease in response to selection by host resistance genes. Hence, the objective of this study was to assess physiologic races of the wheat yellow rust pathogen, their variability and distribution during six cropping seasons (1993–94 to 1998–99) in Syria and Lebanon.

MATERIALS AND METHODS

Virulence surveys of cereal rust fungi have traditionally used differential host genotypes that express resistance in the primary leaves of seedling plants (9). In this study, yellow rust populations were characterized for their virulence pathotypes and pathogenic variations using two methods. The first method was evaluation of seedlings of differential genotypes in growth chambers. A set of the world and European wheat yellow rust differentials as proposed by Johnson et al. (8) was used for this study. Five additional cultivars–lines, Sonalika, Anza, Federation 4/Kavkaz, Gereck 79, and Cham 1, were added, making a total of 22 cultivars–lines (Table 1). The second method was evaluation of differential cultivars in the field under natural conditions. In Syria, wheat yellow rust differentials were planted as a trap nursery at four sites (Fig. 1): northern Syria at Tel Hadya-Aleppo (S1) and northeastern Syria at Kamishly-Al-Hassakeh (S2) in 1994, Tel Hadya-Aleppo, Kamishly-Al-Hassakeh, and

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Accepted for publication 14 December 2001.

northwestern Syria at El Ghab (S3) in 1995, and southern Syria at Jillin (S4) in 1996 and 1997. These sites are located in different agroecological zones distributed from the northeast to the south and represent the major wheat growing areas in Syria (Fig. 1). In Lebanon, the trap nursery was planted at one site in Al Bakka Valley at Terbol (L1) for six consecutive years, 1994 to 1999. Each differential cultivar–line was planted in two rows, 1 m long and 30 cm apart. The differentials were planted in alternate rows with a mixture of susceptible cultivars (spreader rows).

Field natural evaluation of yellow rust infection. Under field conditions, spreader rows served as a source of inoculum. Primary infection by airborne rust spores developed rapidly on the mixture of susceptible cultivars, then subsequent spread of urediniospores occurred naturally on the surrounding plots of the differential cultivars. The trap nursery was evaluated at all testing sites (S1–S4, L1) for six consecutive years (1994 to 1999), except in 1999, when the trap nursery was evaluated only at Tel Hadya (S1) and Terbol (L1) in Syria and Lebanon, respectively. Severity of infection (0 to 100%) and reaction type (R, S) as designated by Peterson et al. (19) were assessed at heading stage (growth stage 85, Zadoks et al. [24]). The frequency of infection of each genotype was calculated as the relative percent frequency of infection of susceptible lines over 6 years at all the testing sites in Syria.

Seedling evaluation under controlled environment. Collections of 40 to 50 infected leaves were obtained at heading stage from differential cultivars in the yellow rust trap nursery and from farm fields in Syria and Lebanon for six consecutive

growing seasons. In the 1998–99 crop season, four yellow rust samples from Yemen and one from Iraq were evaluated. Rust spores (urediniospores) were collected from infected leaves and were increased on seedlings of the wheat cultivar Morocco that had been treated with maleic hydrazide to delay or prevent emergence of secondary leaves. Spores were isolated from all the leaf samples collected. Spores from single uredia were collected and further multiplied in isolation. Urediniospores were used to inoculate 7-day-old seedlings of the yellow rust differential genotypes (Table 1). Inoculated plants were placed for 48 h in a dew chamber at 11°C. They were then transferred to a growth chamber at 17°C with 16 h/8 h day/night. Infection types were assessed 17 days after inoculation using the 0 to 9 scale (18). Infection types equal to or higher than 7 were considered virulent, and those less than 7 were considered avirulent. The physiologic races identified were designated using the nomenclature for *P. striiformis* proposed by Johnson et al. (8). Rust isolates that showed the same physiologic race were omitted to avoid duplication.

RESULTS AND DISCUSSION

Physiologic races. For a period of six consecutive years (1994 to 1999), leaf samples were collected from durum and bread wheat cultivars, as well as from differential cultivars grown under field conditions in Syria and Lebanon (Fig. 1). Single-uredinial isolates of *P. striiformis* were characterized for physiologic races. In Syria, a total of 25 physiologic races were identified during the course of this study (Table 2). Significant changes in race composition were identified using the world and European differential sets (Table 3). The composition of physiologic races found in 1994 and 1999 differed greatly on the world differential set but not as much

on the European differential set. With the exception of race 6E0, which was observed each year of the study, all *P. striiformis* physiologic races identified in this study differed in their occurrence over a 6-year period (1994 to 1999). On the world differential set, the differential genes, *YrSU* and *Yr9+* in Suwon92 × Omar and Clement, respectively, allowed clear discrimination among the races in Syria. Virulence for these genes occurred in 1999 but not in 1994 (Table 2). In the case of the European differential genotypes, virulence for the resistance genes *Yr7+*, *Yr6+*, *Yr2+*, and *Yr8*, and avirulence for *Yr4+*, *YrCV*, and *YrSP*, were observed in the 1994 and 1999 *P. striiformis* populations. The world differential did not allow distinction between four races in 1994 (6E0, 6E134, 6E148, 6E150) and two races in 1999 (6E0, 6E18), whereas European differentials showed differential reactions on *Yr7+*, *Yr6+*, and *Yr8* resistance genes (Table 3) for these races. Thus, the use of both differentials allowed for better discrimination between yellow rust races. In Syria, eight distinct physiologic races were identified in 1999 compared with six races in 1994 (Table 3). Races identified in 1999, such as 230E150 and 230E134, have wider spectra of virulence for yellow rust resistance genes than the races identified in 1994, such as 6E0, 6E148, and 38E150.

The same trends in changes of physiologic race compositions of *P. striiformis* were observed in Lebanon (Table 2). During the first year, only three races were found (6E0, 38E134, and 166E150) compared with six races in 1999 (Table 4). Race 166E150 is among the most virulent races identified and could be among the *P. striiformis* races that contributed most to yellow rust epidemics in this region. Race 166E150 combined virulence for *Yr9+*, *Yr8*, and *YrA* resistance genes, which have been deployed in many bread wheat varie-

Table 1. Host differential genotypes for *Puccinia striiformis*

Host cultivars	Resistance genes
World differentials	
1. Chinese 166	<i>Yr1</i>
2. Lee	<i>Yr7</i>
3. Heines Kolben	<i>Yr6</i> , <i>Yr2</i>
4. Vilmorin	<i>Yr3V</i>
5. Moro	<i>Yr10</i>
6. Strubes Dickopf	<i>YrSD</i>
7. Suwon92 × Omar	<i>YrSU</i>
8. Clement	<i>Yr9</i> , <i>Yr2+</i>
9. <i>Triticum spelta</i>	<i>Yr5</i>
European differential set	
10. Hybrid 46	<i>Yr4+</i>
11. Reichersberg42	<i>Yr7+</i>
12. Heines Peko	<i>Yr6</i> , <i>Yr2+</i>
13. Nord Deprez	<i>Yr3N</i>
14. Compair	<i>Yr8</i> , <i>YrAPR</i>
15. Carstens V	<i>YrCV</i>
16. Spaldings prolific	<i>YrSP</i>
17. Heines VII	<i>Yr2+</i>
Supplemental cultivars	
18. Sonalika	<i>Yr2</i> , <i>YrA</i>
Anza	<i>YrA</i> , <i>Yr18</i>
Fed. 4/Kavkaz	<i>Yr9</i>
Gereck 79	–
Cham 1	–

Fig. 1. Sites of collection of yellow rust samples in Syria and Lebanon.

Table 2. Yellow rust races identified in Syria and Lebanon over 6 years (1994 to 1999)

Physiologic races	Syria				Lebanon
	Tel Hadya	Kamishly-Al-Hassakeh	El Ghab	Jillin	Terbol
2E0	+	+		+	
4E0			+	+	+
6E0	+	+	+	+	+
6E18	+	+			
6E20	+			+	
6E134	+				+
6E144		+			
6E148	+				
6E150	+	+			
18E0				+	
20E148	+				
38E0	+				
38E6	+				
38E22					+
38E128			+		
38E134	+		+	+	+
38E150	+	+			
68E130	+				
70E148			+		+
82E16	+	+	+		
134E16				+	
134E146	+	+	+		
134E150					+
166E150	+				+
172E146					+
182E150					+
198E150					+
230E134	+				
230E150	+				+

^a + = presence of physiologic race.

ties since the early 1980s (20,21). This race has a broad virulence spectrum and was recovered during four consecutive years (1994 to 1997) in Lebanon, but was found in Syria only in 1996 (Table 5). In 1999, virulence for the *YrSu* resistance gene was the major virulence change recorded in Lebanon compared with the results from 1994.

Special leaf collections were made from selected differential genotypes associated with resistance genes, some of which are being exploited in many wheat varieties, and from land race bread wheat cultivars. The selected lines were exposed in trap nurseries to natural yellow rust infection in Syria, Lebanon, Yemen, and Iraq during the same period of the study. One single isolate was tested from each sample and analyzed for race identification. Table 5 shows the *P. striiformis* physiologic races and the corresponding cultivars from which they were isolated. The physiologic races identified from the selected cultivars in the trap nursery were recovered among the 25 and 11 physiologic races identified in Syria and Lebanon, respectively (Table 2). Race 230E150 was found in Iraq, Syria, and Lebanon (Table 5). This race was isolated in Syria from infected leaves of Jupateco R, a cultivar known by its adult plant resistance, and from durum and bread wheat land race cultivars in Lebanon and Iraq, respectively. Race 6E134 was isolated from the differential genotypes Reichersberg42 and Avocet *Yr9* in Syria and Leba-

Table 3. Reaction of host differential genotypes to Syrian yellow rust physiologic races in 1994 and 1999

		Physiologic races ^b and reaction ^c of differential sets													
Wheat– yellow rust differential set	Yr ^a genes	1994						1999							
		6E	6E		20E	6E	38E				38E		230E	230E	68E
		134	148	6E0	148	150	150	6E0	6E18	38E6	134	38E0	134	150	130
World differential set															
Chinese 166	1	1	1	0	0	0	2	0	1	1	1	0	1	1	0
Lee	7	7	7	9	3	7	9	9	8	7	8	7	9	9	0
Heines Kolben	6, 2	7	7	8	7	7	9	8	8	8	9	8	9	9	7
Vilmorin 23	3V	2	3	0	3	3	3	0	1	2	1	1	2	2	0
Moro	10	2	2	0	7	4	3	0	1	1	2	3	3	3	0
Strubens Dickopf	SD	3	4	1	3	4	8	1	1	7	7	8	7	7	1
Suwon92 × Omar	SU	2	3	1	3	4	4	1	1	0	0	1	7	9	7
Clement	9, 2+	3	4	1	2	1	2	1	1	3	1	3	7	7	0
<i>Triticum spelta</i>	5	1	1	1	1	0	0	1	1	3	0	1	1	2	1
European differential set															
Hybrid 46	4+	1	1	1	1	1	1	1	1	1	1	1	1	1	0
Reichersberg42	7+	7	6	1	2	8	8	1	7	7	8	1	8	9	7
Heines Peko	6, 2+	7	7	3	7	7	7	3	1	7	8	2	8	7	3
Nord Desprez	3N	2	3	1	3	6	6	1	1	1	0	1	2	1	3
Compair	8, APR	3	7	3	7	7	7	3	7	1	3	1	4	7	2
Carstens V	CV	1	3	1	3	3	3	1	1	2	1	1	1	0	0
Spaldings prolific	SP	1	1	2	1	0	1	2	1	1	1	0	1	1	0
Heines VII	2+	7	7	3	7	7	7	3	1	1	7	2	8	7	9
Supplemental differential cultivars															
Sonalika	2, A	7	7	6	7	7	8	6	1	1	9	7	8	9	1
Anza	18, A	7	7	7	7	8	8	7	7	3	8	7	6	9	3
Fed. 4/Kavkaz	9	8	8	6	8	8	9	6	1	9	9	9	9	9	9
Gereck 79	–	8	8	7	8	8	9	7	1	1	1	7	9	9	9
Cham 1	–	1	1	1	1	0	2	1	0	2	2	2	2	2	1

^a *Yr* = yellow rust resistance genes.

^b Physiologic races identified in Syria in 1994 and in 1999.

^c Disease reaction scale 0 to 9 (18).

non, respectively. Three virulent physiologic races, 230E150, 134E150, and 4E148, were isolated from leaf samples of the cultivar Jupateco R in Syria, Lebanon, and Yemen, respectively (Table 5). A range of *P. striiformis* races was identified using rust samples developed on cultivars that have specific resistance genes or gene combinations.

Pathogenic variation. The evolution of physiologic races was determined over 6 years (1994 to 1999) in Syria and Lebanon (Table 6). In Syria the number of races evolved from six races in 1994 to 12 races in 1996 compared with three and five races identified in Lebanon in 1994 and 1996, respectively (Table 6). The highest numbers of *P. striiformis* physiologic races in both countries were observed in 1996 and in 1997. In Syria and Lebanon, the 1995 to 1997 crop seasons were considered favorable growing seasons compared with the following seasons, where extended drought periods were important, particularly during the spring.

Physiologic race 6E0 was first observed in the region in 1972 (4). In this study, 6E0 was recovered in Syria and Lebanon for six and four consecutive years, respectively. This race is virulent for *Yr6*, which is frequent in both winter and spring wheat cultivars (17), both of which are cultivated extensively in the highland regions of Syria, Lebanon, Iran, and Turkey. 6E0 is also virulent for *YrA*, which is present in many wheat cultivars that are still cultivated over relatively large areas in Turkey,

Lebanon, and Syria. Race 38E150 was the second most frequent race in Syria and was found for five consecutive years, whereas 134E146 and 38E134 were identified in

rust samples for four consecutive years (Table 6). These races originated from durum wheat leaf samples, and most of them were not detected in 1999, this possi-

Table 5. Yellow rust physiologic races isolated from specific differential lines or wheat cultivars

Country	Wheat differential genotypes-cultivars	Resistance gene or gene combinations	Physiologic races
Syria	Reichersberg42	<i>Yr7+</i>	6E134
	Heines Peko	<i>Yr6, Yr2+</i>	6E148
	Heines Kolben	<i>Yr6</i>	6E0
	Moro	<i>Yr10</i>	20E148
	Corella	<i>Yr6, Yr7</i>	6E18
	Bread wheat cv.	—	38E6
	Reichersberg42	<i>Yr7+</i>	38E134
	Fed. 4/Kavkaz	<i>Yr9</i>	38E0
	Heines VII	<i>Yr2+</i>	230E134
	Jupateco R	<i>Yr18+</i>	230E150
Lebanon	Avocet	<i>Yr8</i>	68E130
	Strubes Dickopf	<i>YrSD</i>	38E134
	Mexipak	—	166E150
	Heines Kolben	<i>Yr6, Yr2</i>	6E0
	Durum wheat cv.	—	230E150
	Avocet	<i>Yr9</i>	6E134
	Avocet	<i>Yr17</i>	38E22
	Jupateco R	<i>Yr18</i>	134E150
	Jupateco S	—	198E150
	Avocet	<i>Yr8</i>	70E148
Yemen	Seri 82	<i>Yr9, Yr7</i>	70E134
	Jupateco R	<i>Yr18+</i>	4E148
	Morocco	—	38E138
	Arona	<i>Yr8</i>	119E158
Iraq			
	Bread wheat (cv. Adnani)	—	230E150

^a + = additional resistance gene(s) present.

Table 4. Reaction of host differential genotypes to Lebanese yellow rust physiologic races in 1994 and 1999

		Physiologic races ^b and reaction ^c of differential sets								
Wheat–yellow rust differential set	Yr ^a genes	1994			1999					
		38E134	6E0	166E150	6E134	38E22	134E150	70E148	198E150	230E150
World differential set										
Chinese 166	<i>1</i>	2	0	1	1	1	0	0	0	0
Lee	<i>7</i>	8	9	7	8	9	9	7	8	8
Heines Kolben	<i>6, 2</i>	8	9	8	8	8	9	7	9	9
Vilmorin 23	<i>3V</i>	3	0	4	2	2	1	2	2	1
Moro	<i>10</i>	2	0	1	3	2	2	2	2	2
Strubes Dickopf	<i>SD</i>	7	1	7	1	9	0	6	3	9
Suwon92 × Omar	<i>SU</i>	1	1	1	2	2	0	8	7	7
Clement	<i>9, 2+</i>	3	1	7	2	2	7	3	7	8
<i>Triticum spelta</i>	<i>5</i>	1	1	1	1	1	1	1	1	0
European differential set										
Hybrid 46	<i>4+</i>	1	1	1	2	1	1	0	1	1
Reichersberg42	<i>7+</i>	7	1	7	7	8	8	3	9	9
Heines Peko	<i>6, 2+</i>	7	3	7	7	7	8	8	7	9
Nord Desprez	<i>3N</i>	4	1	6	1	1	4	0	0	0
Compare	<i>8, APR</i>	4	3	7	1	8	7	7	7	9
Carstens V	<i>CV</i>	2	1	1	2	2	4	2	4	3
Spaldings prolific	<i>SP</i>	1	2	1	1	1	1	1	2	0
Heines VII	<i>2+</i>	7	3	7	7	2	8	8	8	8
Supplemental differential cultivars										
Sonalika	<i>2, A</i>	7	6	1	7	8	9	9	7	8
Anza	<i>18, A</i>	7	4	8	3	4	9	8	8	8
Fed. 4/Kavkaz	<i>9</i>	8	4	8	9	8	9	9	9	9
Gereck 79	–	8	7	8	8	7	9	7	9	8
Cham 1	–	1	1	1	2	1	2	2	1	2

¹ *Yr* = yellow rust resistance genes.

² Physiologic races identified in Lebanon in 1994 and 1999.

³ Disease reaction scale 0 to 9 (18).

bly due to the introduction of a new durum wheat cultivar, Cham5, which has better resistance to yellow rust. In Lebanon, only three physiologic races (6E0, 38E150, 166E150) occurred for four consecutive years in the early 1990's (Table 6). In Syria, six physiologic races of *P. striiformis* were found in 1999. Races 38E6 and 166E150 were also found only once in 1997 and 1996, respectively. In

Lebanon, six races were identified only once during the race survey, five races were found in 1999, and race 20E148 was found only in 1995 (Table 5). Among the races that occurred only once during the period of the study, races 20E148, 134E150, and 230E150 were common in both countries. Other races were observed over 2 to 3 years, particularly in Syria (Table 6).

Fig. 2. Virulence frequency of yellow rust for *Yr* resistance genes in Syria (1994 to 1999).

Table 6. Occurrence of *Puccinia striiformis* physiologic races in Syria and Lebanon, 1994 to 1999

Physiologic race	Country	Years					
		1994	1995	1996	1997	1998	1999
6E0	Syria	+	+	+	+	+	+
	Lebanon	+	+	+	+	-	-
6E148	Syria	+	-	-	-	-	-
6E150	Syria	+	+	+	-	-	-
6E134	Syria	+	-	+	+	-	-
20E148	Syria	+	-	+	+	-	-
	Lebanon	-	+	-	-	-	-
38E150	Syria	+	+	+	+	+	+
38E134	Syria	-	+	+	+	-	+
	Lebanon	+	+	+	+	-	-
166E150	Syria	-	-	+	-	-	-
	Lebanon	+	+	+	+	-	-
6E18	Syria	-	+	+	-	+	+
134 E146	Syria	-	+	+	+	+	-
4E0	Syria	-	+	+	-	-	-
38E128	Syria	-	+	+	-	-	-
6E144	Syria	-	+	-	-	-	-
82E16	Syria	-	+	-	+	-	-
6E20	Syria	-	-	+	+	-	+
172E146	Lebanon	-	-	+	+	-	-
182E150	Lebanon	-	-	+	+	-	-
2E0	Syria	-	-	-	+	+	-
134E16	Syria	-	-	-	+	-	-
18E0	Syria	-	-	-	+	-	-
38E6	Syria	-	-	-	-	+	+
38E0	Syria	-	-	-	-	-	+
38E22	Lebanon	-	-	-	-	-	+
68E130	Syria	-	-	-	-	-	+
70E148	Lebanon	-	-	-	-	-	+
134E150	Syria	-	-	-	-	-	+
	Lebanon	-	-	-	-	-	+
198E150	Lebanon	-	-	-	-	-	+
230E134	Syria	-	-	-	-	-	+
230 E150	Syria	-	-	-	-	-	+
	Lebanon	-	-	-	-	-	+
No. of races	Syria	6	10	12	11	6	9
	Lebanon	3	4	5	5	-	5

^a +/- Presence/absence of *P. striiformis* physiologic race.

New races observed during the course of the study could be attributed to changes in bread wheat varieties being cultivated over large areas, to the extension of resistant durum wheat varieties to irrigated areas in northern Syria, to monoculture of limited numbers of bread wheat varieties, or simply to limited sampling locations.

The frequency of virulence to *Yr* resistance genes (Fig. 2) was determined based on infection of resistant cultivars under field conditions in Syria. Virulence frequencies in the yellow rust population on the differential genotypes tested in the trap nurseries were above 70% for the resistance genes *Yr6*, *Yr7*, *YrA*, and *Yr9*; however, virulence frequencies for *Yr3V* and *YSD* were less than 5%. Virulence frequencies to all other lines were between 15 and 70% (Fig. 2). Diverse virulence phenotypes of *P. striiformis* exist under natural field conditions, and some virulence types could eventually develop and spread over larger areas in the region. Surveys of pathogen populations and the genetic characterization of virulence genes continue to provide valuable information used to design breeding strategies and prioritize which pathogen species and physiologic races to target. *P. striiformis* populations in Syria and Lebanon are genetically diverse, and differences in virulence have been identified. In this study, we showed that composition of *P. striiformis* populations changed over time, and this can be an important consideration for breeding programs. Hence, *P. striiformis* populations should be monitored on a regular basis to determine if new physiologic races occur in a region and whether frequencies of certain races change over time.

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