Identification of New Races of *Puccinia graminis* f. sp. *avenae*

D. E. HARDER, Agriculture Canada Research Station, 195 Dafoe Road, Winnipeg, Manitoba, R3T 2M9

ABSTRACT

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Twenty-two new races of *Puccinia graminis* f. sp. *avenae* were identified from field collections made in Canada since 1985 or from 1,500 isolates held in storage since 1953 at the Agriculture Canada Research Station in Winnipeg. The stored isolates, previously identified by older nomenclature systems, were recovered and reidentified using the current nomenclature of NA races for this pathogen. The new races are listed, along with previously identified races, to provide a key for the known variation in *P. g. avenae* in North America. Samples of the new races are available upon request.

Additional keywords: oat stem rust, physiologic specialization

A revised nomenclature (NA) for races of *Puccinia graminis* Pers.:Pers. f. sp. *avenae* Eriks. & E. Henn. in North America was introduced in 1979 (9). Thirty races, using 10 backcrossed single-gene oat (*Avena sativa* L.) lines as differentials, were originally described. Martens (7) added 22 new races, bringing the number to 52 known NA races in North America.

Approximately 1,500 isolates of *P. g. avenae* have been stored at the Agriculture Canada Research Station in Winnipeg, beginning in 1953. These were obtained mainly from field and nursery collections from across Canada or as greenhouse isolates. The greenhouse isolates had been labeled with coded designations, which in all cases could not be traced as to their origin. In most cases, they would have been derived as single-pustule isolates from field collections or from various greenhouse studies. Collections to 1963 were identified by race numbers based on the differential host set of Stakman et al (12) and continued by Bailey (1) and Newton and Johnston (11). The collections were identified as C-races beginning in 1965 (8) and as NA races after 1978 (9).

A project was initiated in 1988 to rejuvenate all isolates of *P. g. avenae* held in storage at Winnipeg and reidentify them using the NA nomenclature system (9). This paper reports new virulence combinations that were identified in this study and from more recent field collections in Canada.

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MATERIALS AND METHODS

The collections of *P. g. avenae* were stored as urediniospores in vacuum-dried, sealed ampules at 5 C or as fresh urediniospores frozen at −75 C. The vacuum-dried samples were removed from storage, the vacuum seal was broken, and the urediniospores were allowed to rehydrate at room temperature for several hours. Frozen samples were heat-shocked in a water bath at 45 C for 10 min prior to inoculation. Urediniospores were then applied with a sterile spatula to seedling leaves of a susceptible cultivar (Victory or Makuru) that had been moistened with water containing five drops per liter of Tween 20. After inoculation, the plants were incubated overnight at 18 C air temperature in a dew chamber (Percival Model I60-D), then placed on greenhouse benches with 6 hr per day of supplemental fluorescent lighting. Pots containing the seedlings were covered with a plastic chimney to prevent contamination. Where viability of the original collections was low, a second increase of inoculum on the susceptible hosts was performed as above. The genotypes used for race differentiation were backcross lines of *A. sativa* cv. Rodney-O with the single genes *Pg1, Pg2, Pg3, Pg4, Pg8, Pg9, Pg13, Pg15, Pg16*, and *Pga* for stem rust resistance. The PI and RL numbers of the differentials were listed by Martens et al (9). The differentials were planted as a set, six to eight plants per entry, in 20 × 24 × 6 cm fiber trays. Seedling leaves were inoculated by being brushed with the inoculum increase plants and then were incubated in a dew chamber as above. Infection types were scored 14 days after inoculation. All work was performed during the winter months when greenhouse temperatures remained below 22 C.

Virulence combinations that were not previously published (7,9) were given preliminary NA designations, reisolated, and verified by repeated tests. During the course of the study, some erratic reactions by the line with gene *Pg4* were noted. A new source of seed with *Pg4* was obtained from A. P. Roelfs (Cereal Rust Laboratory, St. Paul, MN) to ensure conformity with the differentials used there. All newly identified isolates were retested with this source of *Pg4*.

RESULTS AND DISCUSSION

Twenty-two new races, NA53 through NA74, were identified (Table 1). The geographic origin and year of first isolation are given in Table 2. The identity of the host genotype(s) from which the isolates were obtained in most cases was not known. Seven of the races reacted with mesothetic infection types on the gene *Pg3* differential (Table 1). The effectiveness of gene *Pg3* is environmentally sensitive (7), and lines with this gene could be interpreted as resistant or susceptible, depending on conditions prevailing at the time of identification. Thus, NA54 could possibly be identified as NA26, NA58 as NA55, NA59 as NA10, NA60 as NA8, NA62 as NA61, NA69 as NA11, and NA70 as NA56.

Race NA55 was identified several times in collections from Ontario in 1984 (3) but has not been observed since. Race NA55 is unique in its virulence to gene *Pg16*. This resistance gene was isolated from an accession of the tetraploid species *A. barbata* Brot. (2), originally collected in Israel. Because gene *Pg16* has not been used in commercial production anywhere in North America, it presumably has not influenced North American populations of *P. g. avenae*. However, virulence to "new" resistance

Table 1. Key to races of *Puccinia graminis* f. sp. *avenae* in North America[a]

Race	Effective/ineffective host (*Pg*) genes	Race	Effective/ineffective host (*Pg*) genes	Race	Effective/ineffective host (*Pg*) genes
NA1	1,2,3,4,8,9,13,16,a/15	NA26	8,16,a/1,2,3,4,9,13,15	NA51	3,13,15,16,a/1,2,4,8,9
NA2	1,2,3,4,8,13,16,a/9,15	NA27	9,13,15,16,a/1,2,3,4,8	NA52	8,13,15,16,a/1,2,3,4,9
NA3	1,2,3,4,8,16,a/9,13,15	NA28	9,13,15,16/1,2,3,4,8,a	NA53	1,2,4,13,16,a/3,8,9,15
NA4	1,2,3,8,16,a/4,9,13,15	NA29	9,13,16,a/1,2,3,4,8,15	NA54	3,8,16,a/1,2,4,9,13,15[b]
NA5	1,2,4,8,9,13,16,a/3,15	NA30	13,16,a/1,2,3,4,8,9,15	NA55	8,13,a/1,2,3,4,9,15,16
NA6	1,2,4,8,13,16,a/3,9,15	NA31	1,3,8,16,a/2,4,9,13,15	NA56	1,2,8,9,13,16,a/3,4,15
NA7	1,2,4,8,16,a/3,9,13,15	NA32	1,8,16,a/2,3,4,9,13,15	NA57	2,8,9,13,16,a/1,3,4,15
NA8	1,2,8,16,a/3,4,9,13,15	NA33	1,4,8,13,16,a/2,3,9,15	NA58	3,8,13,a/1,2,4,9,15,16[b]
NA9	1,3,8,13,16,a/2,4,9,15	NA34	1,3,4,8,16,a/2,9,13,15	NA59	1,3,4,8,9,13,16,a/2,15[b]
NA10	1,4,8,9,13,16,a/2,3,15	NA35	2,4,8,13,16,a/1,3,9,15	NA60	3,4,8,9,13,16,a/1,2,15[b]
NA11	1,8,9,13,16,a/2,3,4,15	NA36	2,8,13,16,a/1,3,4,9,15	NA61	4,8,13,16,a/1,2,3,9,15
NA12	1,8,13,16,a/2,3,4,9,15	NA37	2,8,16,a/1,3,4,9,13,15	NA62	3,4,8,13,16,a/1,2,9,15[b]
NA13	1,13,16,a/2,3,4,8,9,15	NA38	1,2,3,4,8,13,15,16,a/9	NA63	4,9,13,16,a/1,2,3,8,15
NA14	2,3,4,9,13,15,16,a/1,8	NA39	1,2,4,8,9,13,15,16,a/3	NA64	1,3,4,8,13,16,a/2,9,15
NA15	2,4,8,9,13,15,16,a/1,3	NA40	1,3,8,13,15,16,a/2,4,9	NA65	2,3,4,8,13,16,a/1,9,15
NA16	2,4,9,13,15,16,a/1,3,8	NA41	1,4,8,13,15,16,a/2,3,9	NA66	2,8,9,15,16,a/1,3,4,13
NA17	2,4,9,13,15,16/1,3,8,a	NA42	1,4,8,16,a/2,3,9,13,15	NA67	16,a/1,2,3,4,8,9,13,15
NA18	2,4,9,13,16,a/1,3,8,15	NA43	1,8,9,13,15,16,a/2,3,4	NA68	13,15,16,a/1,2,3,4,8,9
NA19	3,8,9,13,16,a/1,2,4,15	NA44	2,3,9,13,15,16,a/1,4,8	NA69	1,3,8,9,13,16,a/2,4,15[b]
NA20	3,8,13,16,a/1,2,4,9,15	NA45	2,4,8,13,15,16,a/1,3,9	NA70	1,2,3,8,9,13,16,a/4,15[b]
NA21	3,9,13,15,16,a/1,2,4,8	NA46	2,4,8,13,15,16/1,3,9,a	NA71	2,3,8,13,16,a/1,4,9,15
NA22	4,8,9,13,16,a/1,2,3,15	NA47	2,4,8,16,a/1,3,9,13,15	NA72	3,13,16,a/1,2,4,8,9,15
NA23	4,9,13,15,16,a/1,2,3,8	NA48	2,4,13,15,16,a/1,3,8,9	NA73	3,4,8,9,13,15,16,a/1,2
NA24	8,9,13,16,a/1,2,3,4,15	NA49	2,8,13,15,16,a/1,3,4,9	NA74	1,2,8,13,16,a/3,4,9,15
NA25	8,13,16,a/1,2,3,4,9,15	NA50	3,4,9,13,15,16,a/1,2,8		

[a]Races NA1 through NA52 were described previously (7,9).
[b]These newly described pathotypes normally show a mesothetic reaction on lines with gene *Pg3*.

Table 2. Newly described races of *Puccinia graminis* f. sp. *avenae* and location and year of first isolation[a]

Race	Location, date
NA53	Saskatchewan, 1983
NA54	Ontario, 1963
NA55	Ontario, 1984
NA56	Saskatchewan, 1969
NA57	Manitoba, 1968
NA58	Greenhouse isolate from a culture of NA55, 1991
NA59	British Columbia, 1987
NA60	Greenhouse isolate, 1962
NA61	Ontario, 1957
NA62	Ontario, 1954
NA63	Nova Scotia, 1955
NA64	Manitoba, 1956
NA65	Nova Scotia, 1957
NA66	Greenhouse isolate, 1968
NA67	Manitoba, 1964
NA68	Manitoba, 1966
NA69	Ontario, 1966
NA70	British Columbia, 1989
NA71	Manitoba, 1969
NA72	Manitoba, 1958
NA73	Manitoba, 1960
NA74	British Columbia, 1964

[a]All isolates are from field collections except NA60 and NA66, the origins of which are unknown.

genes may be resident in populations of *P. g. avenae*. I have documented (*unpublished*) high incidences of virulence to genes *Pg13* and *Pg15* in historic collections of *P. g. avenae* in Canada. The latter genes were derived from accessions of *A. sterilis* L. (7), and only *Pg13* has been used in commercial production, beginning with the cultivar Fidler in 1981 (10). Another interesting race is NA67, which is unique in combined virulence to genes *Pg8* and *Pg13*. This is the first and only isolate known with virulence to this gene combination.

The newly described pathotypes should be useful for extending the selection of virulence phenotypes to be used as tools in host/pathogen interaction studies. These pathotypes have been restored at the Agriculture Canada Research Station in Winnipeg and are available upon request. Samples also have been forwarded to the USDA Cereal Rust Laboratory in St. Paul, Minnesota.

The list of races after NA52 in Table 1 supersedes any other race designations that may have been reported previously. Races NA81 and NA82 (4,6) are to be corrected as races NA18 and NA16, respectively, due to their reevaluation on *Pg4*. Race NA80 (4,5) is corrected as NA68, and NA75 (6) as NA73.

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