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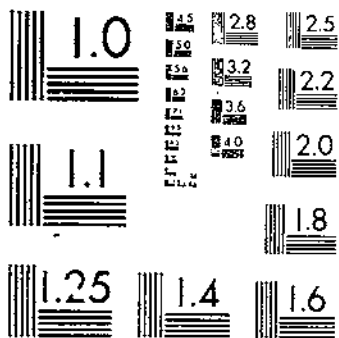
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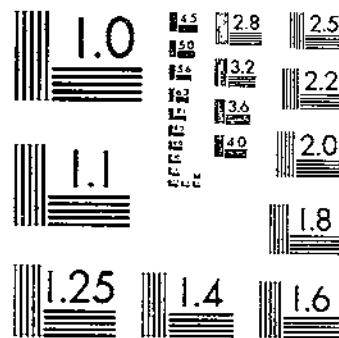
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**Physiologic Races of
Puccinia recondita f. sp. *tritici*
in the United States
From 1926 Through 1960**

J. L. H. B.
Les. Agr. et. Public. Lancer

Technical Bulletin No. 1393

Agricultural Research Service
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CONTENTS

	Page
Materials and methods.....	2
Results.....	3
Prevalence of physiologic races by years and by 5-year periods.....	4
Prevalence of physiologic races by States...	7
Prevalence of physiologic races by geo- graphic areas and classes of wheat grown..	10
Prevalence of physiologic races by UN race..	10
Summary.....	17
Literature cited.....	18

Physiologic Races of *Puccinia recondita* f. sp. *tritici* in the United States From 1926 Through 1960¹

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Studies of physiologic specialization in the fungus causing leaf rust of wheat, *Puccinia recondita* Rob. ex Desm. f. sp. *tritici*, were started by Mains and Jackson (?)³ at Purdue University in 1918. They established a set of 11 differential varieties of wheat and described 12 physiologic races of the fungus. Three varieties were soon discarded and the remaining eight (8) became known as the International Standard differential varieties. These varieties have been used in many countries as a basis for race identification. The races reported have been recorded in an International Register of Physiologic Races of the fungus through several revisions (4, 5)⁴ coordinated by the late senior author of this bulletin.

Beginning in 1926, collections of *P. recondita* f. sp. *tritici* in wheat-growing areas of the United States were analyzed for their physiologic race content each year. Summaries of results were published each year from 1951 through 1960, but no long-term summary has been made. This bulletin summarizes data obtained from 1926 through 1960.

¹ This bulletin is listed by the Department of Plant Pathology, Kansas Agricultural Experiment Station, Manhattan, as Contribution No. 492, and by the Purdue University Agricultural Experiment Station, Lafayette, as Journal Paper No. 3183.

² Deceased, November 1967.

³ Italic numbers in parentheses refer to Literature Cited, p. 18.

⁴ Also, HUMPHREY, H. B., JOHNSTON, C. O., and CALDWELL, R. M. A REVISION OF THE NUMBERS ASSIGNED TO PHYSIOLOGIC RACES OF THE LEAF RUST OF WHEAT, *PUCCINIA TRITICINA* ERIKSS. U.S. Dept. Agr., Bur. Plant Indus., Div. Cereal Crops and Dis., 14 pp. 1936. [Mimeographed.]

HUMPHREY, H. B., JOHNSTON, C. O., CALDWELL, R. M., and COMPTON, L. E. REVISED REGISTER OF PHYSIOLOGIC RACES OF THE LEAF RUST OF WHEAT (*PUCCINIA TRITICINA*). U.S. Dept. Agr., Bur. Plant Indus., Div. Cereal Crops and Dis., 18 pp. 1939. [Mimeographed.]

JOHNSTON, C. O., HUMPHREY, R. M., CALDWELL, R. M., and COMPTON, L. E. THIRD REVISION OF THE INTERNATIONAL REGISTER OF THE PHYSIOLOGIC RACES OF THE LEAF RUST OF WHEAT (*PUCCINIA RUBIGO-VERA TRITICI* (*TRITICINA*)). U.S. Dept. Agr., Bur. Plant Indus., Div. Cereal Crops and Dis., 20 pp. 1942. [Mimeographed.]

JOHNSON, C. O., and RODENHISER, H. A. FOURTH REVISION OF THE INTERNATIONAL REGISTER OF PHYSIOLOGIC RACES OF THE LEAF RUST OF WHEAT (*PUCCINIA RUBIGO-VERA TRITICI* (*TRITICINA*)). U.S. Dept. Agr., Bur. Plant Indus., Soils and Agr. Engin. 203 cc, 15 pp. 1951. [Mimeographed.]

MATERIALS AND METHODS

Leaf rust, caused by *P. recondita* f. sp. *tritici*, was collected from wheat in experimental sowings, commercial plantings, roadsides, and volunteer fields by the writers of this bulletin and other plant scientists or interested persons. Collections were refrigerated at about 45° F. until analyzed.

From 1926 through 1946, most collections from east of the Mississippi River were analyzed at Lafayette, Ind., while those west of the Mississippi were analyzed at Manhattan, Kans. After 1946, all collections were analyzed at Manhattan. Methods used at the two stations were about the same.

The number of collections analyzed varied from year to year. In general, fewer collections were analyzed during early years of the studies, and more analyzed in years when leaf rust was severe in the United States.

During some years the number of viable collections (those yielding cultures) was greatly reduced because urediospores lost their viability during shipment or because refrigerators failed. Only viable collections were accessioned. Cultures were obtained from collections made in 40 States. In general, viable collections were obtained from only a few States in the early years of the studies, but from many States from 1949 through 1960 (table 1).

Beginning about October 1 each year, seedlings of the differential wheat varieties or a susceptible variety were inoculated with urediospores from the leaf rust collections. The urediospores were transferred by scalpel to primary leaves of the seedlings. If the initial inoculum was limited, a completely susceptible variety, not the differential varieties, was inoculated. Inoculated seedlings were atomized with water, placed in moist chambers, usually overnight, and then removed to a greenhouse maintained at 65° to 75° F. When the resulting pustules were vigorously sporulating, usually about 12 days later, several high infection type pustules were individually cultured on a susceptible variety. When only a few pustules sporulated, each was cultured. If high infection types occurred on two or more differential varieties, pustules from each variety were cultured to increase the probability of obtaining pure cultures of different races. These pure cultures will hereafter be referred to as isolates to distinguish them from original cultures.

Plants inoculated with urediospores from single pustules were incubated the same as the original cultures except when these seedlings were removed from the moist chamber, a glass lantern chimney was placed over each isolate to protect it from contamination by nearby isolates. After about 12 days, urediospores from these isolates were used to inoculate seedlings of the International Standard differential varieties, again using the same incubation techniques. Infection types produced by each isolate on each differential variety were recorded after 10 to 12 days according to the scale of Mains and Jackson (7) and isolates were identified as to race according to the keys in the International Registers of Physiologic Races (4, 5)⁵

⁵ See footnote 4, p. 1.

RESULTS

Data on prevalence of physiologic races of *P. recondita* f. sp. *tritici* are presented in this bulletin by years and by 5-year periods (tables 1, 2, and 3), by States (tables 4 and 5), by geographic areas and classes of wheat grown (table 6), and by Unified Numeration (UN) races (table 7).

TABLE 1.—Number of collections of *Puccinia recondita* f. sp. *tritici* analyzed, number of States represented, and number of physiologic races identified in the United States from 1926 through 1960

Year	Collections analyzed ¹	States represented	Races identified
	Number	Number	Number
1926.....	5	5	9
1927.....	55	6	9
1928.....	67	12	14
1929.....	46	11	13
1930.....	133	10	18
1931.....	156	15	17
1932.....	75	15	20
1933.....	40	9	10
1934.....	30	8	9
1935.....	58	8	26
1936.....	46	10	18
1937.....	48	13	13
1938.....	52	13	13
1939.....	95	14	29
1940.....	126	16	23
1941.....	107	14	26
1942.....	96	14	22
1943.....	49	12	10
1944.....	128	11	25
1945.....	119	14	22
1946.....	115	12	24
1947.....	66	11	16
1948.....	102	16	15
1949.....	316	27	14
1950.....	348	30	14
1951.....	252	26	29
1952.....	208	29	24
1953.....	215	22	24
1954.....	313	32	26
1955.....	285	30	22
1956.....	218	23	23
1957.....	332	28	24
1958.....	295	28	22
1959.....	402	33	23
1960.....	175	22	16

¹ Total from 1926 through 1960—5,166.

Prevalence of Physiologic Races by Years and by 5-Year Periods

From 1927 through 1960, 5,166 collections of leaf rust were cultured and analyzed; the number cultured and analyzed in 1926 was not recorded (table 1). Collections from 1926 through 1960 yielded 16,153 isolates from which 100 physiologic races were identified (table 2). Sixty-six of these races were first described from collections made in the United States; 34 were first described from collections made in other countries (4).

Sixty-six of the one hundred races were isolated 30 or fewer times from 1926 through 1960 and were arbitrarily considered to be of minor economic importance. The other 34 were isolated nearly every year or were very prevalent at some time during the 35 years of the studies and were considered to be of major economic importance.

TABLE 2.—*Physiologic races of Puccinia recondita f. sp. tritici identified from field collections of leaf rust in the United States from 1926 through 1960*

Race	Year first identified in United States	Years identified	Times identified ¹	Race	Year first identified in United States	Years identified	Times identified ¹
		Number	Number			Number	Number
1.....	1921	18	77	30.....	1928	10	30
2.....	1921	29	483	31.....	1928	30	100
3.....	1921	17	72	32.....	1928	7	11
4.....	1921	2	2	33.....	1928	14	37
5.....	1920	35	2,668	34.....	1931	2	4
6.....	1922	20	377	35.....	1926	22	224
7.....	1921	1	3	36.....	1927	2	10
9.....	1920	55	1,778	37.....	1926	15	90
10.....	1920	21	88	38.....	1927	3	5
11.....	1923	30	432	39.....	1928	6	19
12.....	1922	2	3	40.....	1928	3	7
13.....	1926	23	116	41.....	1929	4	4
14.....	1941	1	2	42.....	1929	4	11
15.....	1927	33	3,103	43.....	1929	6	12
16.....	1951	2	5	44.....	1926	21	252
17.....	1950	2	3	45.....	1926	11	24
18.....	1932	4	7	46.....	1926	4	4
19.....	1926	28	427	47.....	1930	1	2
20.....	1928	22	245	48.....	1926	1	1
21.....	1947	6	62	49.....	1930	6	15
25.....	1935	1	1	50.....	1926	10	88
26.....	1927	6	18	51.....	1932	1	1
27.....	1926	3	3	52.....	1931	15	216
28.....	1926	20	160	53.....	1938	2	8
29.....	1927	4	7	54.....	1944	9	274

TABLE 2.--*Physiologic races of Puccinia recondita f. sp. tritici identified from field collections of leaf rust in the United States from 1926 through 1960*—Continued

Race	Year first identified in United States	Years identified	Times identified ¹	Race	Year first identified in United States	Years identified	Times identified ¹
		Number	Number			Number	Number
55	1932	3	21	102	1932	3	10
53	1932	3	5	103	1931	8	28
57	1926	1	2	104	1931	10	28
58	1939	21	772	105	1931	23	900
60	1950	2	17	106	1939	1	1
61	1942	2	8	108	1940	1	1
64	1935	11	38	110	1939	1	1
65	1931	15	132	111	1939	2	3
68	1938	1	1	112	1939	2	2
69	1959	1	1	113	1939	3	2
74	1939	1	1	114	1942	2	3
76	1931	16	168	115	1951	1	1
77	1931	12	81	117	1952	2	2
78	1932	3	6	120	1952	1	1
79	1932	8	19	122	1944	11	752
80	1932	13	75	123	1941	1	4
81	1933	5	7	126	1941	19	1, 155
82	1933	1	1	127	1953	1	3
83	1933	5	7	128	1944	7	53
84	1935	3	10	129	1942	1	1
88	1941	2	3	130	1957	3	30
90	1939	2	3	131	1953	7	41
93	1945	11	143	140	1957	2	4
100	1937	1	1	143	1956	3	4
101	1938	6	9	161	1956	1	1

¹ Total isolates from 1926 through 1960—16,153.

The number of physiologic races identified each year during the studies is shown in table 1. The number varied from 9 to 29, generally with fewer races in the early years and more in the later years when the studies were more extensive. Annual records of the number of isolates of each race identified were too extensive to present here; however, changes in prevalence of some major races are shown in figure 1. Race 9 was the most prevalent race identified from the beginning of the studies until the late 1940's, when it decreased markedly and race 5 became the most prevalent race. Race 5 continued to be the most prevalent race from 1949 until 1956. Race 15 has been a prevalent race each year of the studies since 1930. It was second or third most prevalent nearly every year from 1930 through 1955 and since then has been the most prevalent race. Races 58 and 105

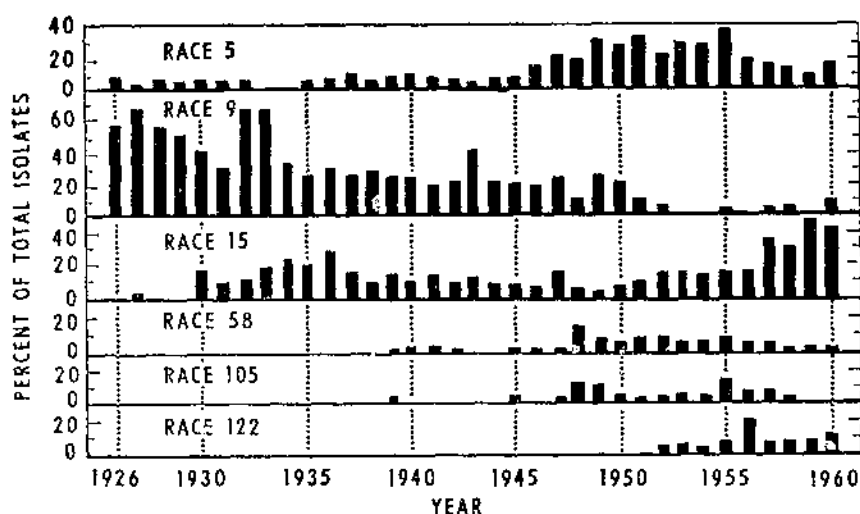


FIGURE 1.—Percentage of total isolates represented by 6 major physiologic races of *Puccinia recondita* f. sp. tritici in the United States each year from 1926 through 1960.

suddenly became prevalent in 1948, Race 122 was first identified in the United States in 1911 but did not become prevalent until 1952. It was the most prevalent race identified in 1956 and is still prevalent in some areas.

Among the 34 races isolated 31 or more times, 22 were isolated one hundred or more times. Prevalence of those 22 races and 5 others of special interest during successive 5-year periods is shown in table 3. Race 1 never became prevalent in the United States as a whole, even though it was one of the first 12 races described and was sometimes prevalent in Idaho, Utah, and Washington. Race 3 was prevalent during the early years of the studies, but has not been identified recently. Race 10 was often identified in trace amounts but was never prevalent. Race 77 is of interest because it produces a type I infection on all the International Standard differential varieties. It was first identified in 1931, but was never prevalent. Race 128 was first identified in the United States and Canada in 1911, was prevalent through 1946, and then decreased to one isolate each year for a few years. It has not been identified from U.S. collections since 1952.

Races 65 and 76 were prevalent in the Eastern United States in the 1930's but since then have either decreased or disappeared. On the other hand, races 58, 122, and 126 were prevalent only in the later years of these studies.

The other races shown in table 3 were prevalent in the United States at some time. Some of them, such as races 5, 9, and 15, were identified nearly every year and were the most prevalent races in different areas at various times.

TABLE 3.—Prevalence of 27 physiologic races of *Puccinia recondita* f. sp. *tritici* in the United States by successive 5-year periods from 1926 through 1960

Race	Percentage of total isolates during—						
	1926-30	1931-35	1936-40	1941-45	1946-50	1951-55	1956-60
1.....	0.2	0.8	0.1	0.07	0.1	0.8	0.7
2.....	1.9	1.1	2.1	1.0	0.9	3.6	5.2
3.....	3.7	1.8	2.5	0.6	0.2	0	0
5.....	2.7	2.1	5.4	3.9	22.3	28.1	13.2
6.....	0.4	0	0.7	0.9	0.6	3.8	3.8
9.....	49.0	27.9	23.0	19.5	17.8	2.4	2.8
10.....	1.0	1.1	1.3	0.5	0.2	0.9	0.2
11.....	1.0	0.5	1.5	1.3	2.7	4.5	3.8
13.....	7.2	1.6	2.3	1.6	0.3	0.2	0.1
15.....	5.0	17.8	14.9	10.6	7.8	15.4	37.4
19.....	4.0	4.6	4.1	6.5	0.6	2.2	2.5
20.....	1.4	1.1	0.8	1.6	0.7	1.6	2.3
28.....	0.0	0.3	4.8	0.6	0.4	1.4	0.4
31.....	2.1	1.8	3.8	2.1	0.5	0	0
35.....	2.1	0.3	0.4	0.7	0.5	3.8	0.4
44.....	0.6	3.3	3.9	8.2	1.7	0.4	0
52.....	0.2	0	0.2	0.1	0.9	3.1	1.0
54.....	0	0	0	0.1	0	2.3	3.8
58.....	0	0	0.6	1.9	8.0	7.9	3.2
65.....	0	13.1	1.2	0.8	0.2	0	0
76.....	0	6.7	4.2	3.4	0.7	0.02	0
77.....	0.2	0	0	0	0.4	0.4	1.1
93.....	0.4	0	0	0.1	1.9	1.4	0.1
105.....	0	0.3	2.2	2.8	9.0	8.4	4.1
122.....	0	0	0	0.1	0.03	5.6	10.0
126.....	0	0	0	16.6	15.4	7.2	2.4
128.....	0	0	0	2.6	0.5	(¹)	0

¹ Trace.

Prevalence of Physiologic Races by States

Table 4 shows the most prevalent race in each State during each 5-year period of these studies. No viable collections were obtained from some States during certain 5-year periods. Race 11 was the most prevalent race in California, Idaho, Oregon, and Washington throughout the studies, or at least since about 1935. Race 58 was the most prevalent race in Maryland, Michigan, New York, and Ohio for many years.

The possibility of rapid, important changes in prevalence of races is shown by comparing prevalence and distribution of the races in successive 5-year periods (table 4). From 1941 through 1945, race 9 and related race 19 were the most prevalent races in 14 of the 28 States from which rust collections were analyzed. From 1946 through 1950,

TABLE 4.—Prevalence of major races of *Puccinia recondita* f. sp. *tritici* in the United States by States in successive 5-year periods from 1926 through 1960

State	Total races	Total isolates ¹	Most prevalent race during—						
			1926-30	1931-35	1936-40	1941-45	1946-50	1951-55	1956-60
	<i>Number</i>	<i>Number</i>							
Alabama.....	19	468			9	93	9	5	15
Arizona.....	2	3	9	19		9			
Arkansas.....	24	206		9		15	126	5	15
California.....	16	88	9	19		11	11	11	11
Colorado.....	18	196	2	9	9	9	9	5	15
Florida.....	26	425		15			5	5	15
Georgia.....	33	496	9	15	15	65	5	122	122
Idaho.....	25	234		11	11	11	11	11	11
Illinois.....	40	370		15	9	9	58	58	122
Indiana.....	34	348		15	9		58	58	122
Iowa.....	34	770	9	9	9	9	5	5	15
Kansas.....	65	3,408	9	9	9	9	5	5	15
Kentucky.....	21	103		15	76	76	5	5	15
Louisiana.....	7	30						5	15
Maine.....	3	4		80					
Maryland.....	13	47				76	58		58
Michigan.....	42	559		15	9	9	58	58	58
Minnesota.....	38	842	37	9	9	9	105	15	15
Mississippi.....	19	297			15		5	5	15
Missouri.....	37	422	9	9	9	9	126	5	15

Montana.....	17	64	9	13	-----	19	9	15	-----
Nebraska.....	36	557	9	9	9	9	9	5	15
New Mexico.....	15	121	-----	-----	-----	-----	-----	5	15
New York.....	18	179	-----	15	9	-----	58	58	58
North Carolina.....	25	190	-----	65	15	-----	58	5	15
North Dakota.....	42	676	9	-----	9	9	5	5	15
Ohio.....	31	326	-----	15	76	76	58	58	58
Oklahoma.....	35	660	9	9	9	9	5	5	15
Oregon.....	14	37	11	-----	11	11	-----	11	11
Pennsylvania.....	11	43	-----	55	9	-----	58	58	15
South Carolina.....	29	551	-----	-----	-----	-----	5	5	15
South Dakota.....	32	280	9	15	9	9	5	5	15
Tennessee.....	20	133	-----	65	-----	-----	5	5	122
Texas.....	47	1,306	9	9	9	9	5	5	15
Utah.....	4	7	-----	-----	-----	-----	11	-----	-----
Virginia.....	43	462	-----	15	9	15	58	58	15
Washington.....	24	121	9	1	11	11	11	11	11
West Virginia.....	11	41	-----	-----	9	15	15	58	15
Wisconsin.....	35	373	-----	15	9	15	5	5	15
Wyoming.....	16	99	-----	9	-----	-----	9	5	15

¹ Total isolates from 1926 through 1960—15,542. During the early years of the study, not all collections were accessioned by State; therefore, some are not accounted for in this table.

race 9 was the most prevalent race in only 5 of the 35 States, while race 5 was the most prevalent in 13 States. Race 5 was the most prevalent race in 21 of the 36 States from 1951 through 1955, while it was not the most prevalent in any State from 1956 through 1960. Race 15 was the most prevalent race in 24 of the 36 States from 1956 through 1960.

Data of prevalence of 12 major races expressed as percentages of total isolates of all races in the period 1926 through 1960 are shown in table 5. Marked differences in distribution of races are shown by these data. For example, race 9 constituted 22.1 percent of the isolates from Oklahoma, but only 12.0 percent of the isolates from North Dakota. Race 15 constituted only 11.1 percent of the isolates from Oklahoma, but 23.1 percent of the isolates from North Dakota. Many other such cases may be noted, indicating definite differences in geographic distribution of various races.

Prevalence of Physiologic Races by Geographic Areas and Classes of Wheat Grown

The prevalence of 12 major physiologic races of *P. recondita* f. sp. *tritici* by geographic areas and by classes of wheat grown is shown in table 6. Other races, not listed in table 6, were identified much less frequently than any of the 12 major races.

Race 5 was fairly prevalent in all areas except the western, white wheat area, but was more prevalent in the southeastern, soft red winter wheat area than in the northeastern. Race 6 was not more prevalent in any one geographic area than another, except that it was definitely infrequent in the western area. Race 9 was prevalent in the central, hard red winter and the north central, hard red spring wheat areas, and was for many years the most prevalent race. Only 10 races were identified from the western area, and race 11 was by far the most prevalent. Race 11 was often the only race in collections from the western area and was prevalent only in that area. Race 15 was prevalent in all areas except the western; it was the most prevalent race in the north central, the northeastern, and the southeastern areas. Race 38 was particularly prevalent in the States around the Great Lakes and in the Ohio River valley.

Races 105 and 126 were both prevalent in all areas except the western. Race 122 was the most prevalent race in the southeastern area, particularly in Georgia, Mississippi, South Carolina, and Virginia. Races 1, 65, and 76 were identified relatively infrequently. Race 1 was isolated mostly from the western area, races 65 and 76 from the northeastern.

Prevalence of Physiologic Races by UN Race

During the 35 years of these studies, it became evident that many races of *P. recondita* f. sp. *tritici* could be placed into a few large groups composed of several similar races. Members of these groups were sometimes inseparable, while at other times they were distinct. This difference was caused by varying reactions of the differential varieties Carina, Brovit, and Hussar under varying environmental

TABLE 5.—Percentage of total isolates represented by 12 major physiologic races of *Puccinia recondita* f. sp. tritici in the United States from 1926 through 1960

State	Percentage of total isolates represented by physiologic race—												Isolates of 12 major races ¹	Isolates of all races ²
	1	5	6	9	11	15	58	65	76	105	122	126		
Alabama.....	0.0	20.3	2.6	5.3	0.6	23.1	2.0	0.0	0.0	6.0	8.1	8.1	Number 349	Number 468
Arizona.....	0	0	0	.33	0	0	0	0	0	0	2.3	0	1	3
Arkansas.....	1.5	20.9	2.4	6.8	0	26.2	.5	0	0	1.0	11.7	8.3	163	206
California.....	0	1.1	1.1	1.1	61.4	6.8	3.4	0	0	0	2.3	2.3	70	88
Colorado.....	0	15.8	2.6	29.1	0	17.9	1.0	0	0	6.6	2.5	4.5	157	196
Florida.....	.2	33.4	1.2	8.0	1.9	25.9	3.3	.5	0	3.8	4.7	4.5	371	425
Georgia.....	.2	14.7	.6	4.0	.4	11.9	2.4	2.2	1.6	6.7	18.1	6.7	345	496
Idaho.....	10.7	7.7	.4	3.4	35.9	3.0	8.5	0	0	1.7	1.3	1.7	174	234
Illinois.....	.5	12.4	3.5	5.7	2.4	16.2	8.4	3.0	3.5	7.8	9.7	6.2	294	370
Indiana.....	0	7.8	.9	9.5	0	13.5	8.6	10.1	11.8	3.7	1.7	2.9	245	348
Iowa.....	.1	19.7	3.8	13.5	.5	39.7	2.6	0	0	6.4	2.2	8.8	597	770
Kansas.....	.2	16.6	2.7	18.2	.6	20.3	1.1	0	.02	4.5	2.7	7.5	2,536	3,408
Kentucky.....	0	29.1	0	10.7	0	22.3	8.7	4.9	11.7	1.9	0	4.9	82	103
Louisiana.....	0	26.7	0	0	0	23.3	13.3	0	0	6.7	23.3	0	28	30
Maine.....	0	0	0	0	0	50.0	0	0	50.0	0	0	0	2	4

See footnotes at end of table.

TABLE 5.—Percentage of total isolates represented by 12 major physiologic races of *Puccinia recondita* f. sp. *tritici* in the United States by States from 1926 through 1960—Continued

State	Percentage of total isolates represented by physiologic race—												Isolates of 12 major races ¹	Isolates of all races ²
	1	5	6	9	11	15	58	65	76	105	122	126		
Maryland	0	0	8.5	2.1	0	17.0	25.5	0	17.0	2.1	0	8.5	Number 38	Number 47
Michigan	.2	10.9	2.5	5.0	.4	18.8	12.7	2.5	2.0	10.4	9.7	5.9	452	559
Minnesota	0	19.1	3.0	4.6	.5	33.7	2.1	0	0	6.1	3.1	9.3	686	842
Mississippi	0	18.5	1.7	2.7	1.7	23.9	3.0	0	0	7.7	15.2	9.4	249	297
Missouri	0	16.4	2.6	9.7	1.4	16.1	2.8	0	0	6.6	7.3	10.7	311	422
Montana	0	17.2	0	10.9	0	23.4	0	0	0	0	1.6	4.7	37	64
Nebraska	.2	22.4	2.3	26.2	.2	14.2	1.1	0	0	4.7	.9	9.0	452	557
New Mexico	0	22.3	5.8	6.6	0	12.4	1.7	0	0	6.6	2.5	19.0	93	121
New York	0	3.9	.6	1.1	9.5	7.3	53.1	0	1.7	8.9	1.1	2.8	161	179
North Carolina	.5	14.7	0	3.7	.6	22.1	21.1	1.6	2.6	8.4	2.6	2.1	152	190
North Dakota	.1	19.8	1.2	12.0	1.6	23.1	1.5	0	.1	5.6	1.6	7.2	500	676
Ohio	0	5.8	1.8	5.8	0	13.2	21.8	6.4	9.2	2.5	7.1	3.1	250	326
Oklahoma	0	15.2	3.5	22.1	.6	11.1	1.4	0	0	8.0	1.8	11.8	498	660
Oregon	2.7	2.7	0	24.3	24.3	13.5	2.7	0	0	0	0	2.7	27	37
Pennsylvania	0	14.0	4.7	4.7	0	37.2	20.9	4.7	2.3	2.3	0	2.3	40	43

South Carolina.....	0	19.6	.7	3.1	.4	31.8	7.6	.2	.5	6.4	10.9	4.4	471	551
South Dakota.....	0	20.7	5.0	12.5	2.5	17.5	1.8	0	0	5.4	1.4	10.0	215	280
Tennessee.....	0	17.3	0	.8	3.0	24.8	9.8	2.3	.8	8.3	9.0	3.8	106	133
Texas.....	.1	19.2	4.1	17.8	2.0	16.1	2.0	0	0	5.0	3.2	5.7	981	1306
Utah.....	14.3	0	0	0	57.1	0	0	0	0	14.3	0	0	6	7
Virginia.....	0	12.3	1.3	1.9	2.2	29.9	9.3	1.1	3.0	4.8	8.0	4.1	360	462
Washington.....	11.6	3.3	0	2.5	38.8	3.3	8.3	0	0	.8	2.5	3.3	90	121
West Virginia.....	0	12.2	0	0	0	43.9	4.9	2.4	2.4	12.2	0	9.8	36	41
Wisconsin.....	0	10.7	3.1	7.0	1.6	16.9	7.5	5.1	3.8	8.3	6.2	7.8	287	373
Wyoming.....	0	19.2	8.1	10.1	3.0	16.2	1.0	0	0	12.1	3.0	3.0	75	99
Percentage of total isolates.....	.4	16.6	2.5	11.7	2.3	19.7	4.7	.9	1.0	5.6	4.8	7.0	77.1	100

¹ Total isolates of 12 major races—11,987.

² Total isolates of all races—15,542. During the early years of the study, not all collections were accessioned by State; therefore, some are not accounted for in this table.

TABLE 6.—Percentage of total isolates represented by 12 major physiologic races of *Puccinia recondita* f. sp. tritici in the United States by 5 major geographic areas and classes of wheat grown from 1926 through 1960

Geographic area and class of wheat grown	States ¹	Percentage of total isolates of physiologic race—											Isolates of all races ²	
		1	5	6	9	11	15	58	65	76	105	122		126
	<i>Number</i>													<i>Number</i>
CENTRAL, Hard red winter	7	0.2	17.6	3.1	19.2	0.9	17.7	1.3	0.0	0.02	5.2	2.6	7.8	6,347
NORTH CENTRAL, Hard red spring	6	.1	18.5	2.8	9.7	1.1	23.5	2.7	.6	.5	6.1	2.4	8.5	3,005
NORTHEASTERN, Soft red winter	11	.2	11.3	2.3	6.7	1.3	16.9	13.2	3.3	4.6	6.1	6.8	5.9	2,607
SOUTHEASTERN, Soft red winter	10	.1	19.2	1.1	3.6	1.1	24.6	6.2	.8	1.1	6.2	11.1	7.9	3,093
WESTERN, White	6	8.4	4.9	.4	4.5	44.7	4.5	6.8	0	0	1.2	1.6	2.3	490
Percentage of total isolates in all areas		.4	16.6	2.5	11.7	2.3	19.7	4.7	.9	1.0	5.6	4.8	7.0	

¹ Total number of States—40.² Total isolates of all races—15,542. During the early years of the study, not all collections were accessioned by State; therefore, some are not accounted for in this table.

conditions, particularly temperature. These varieties were resistant to some isolates at low or moderate temperatures and susceptible to the same isolates at high temperatures (8). However, similar races can be brought together into more consistently identifiable groups by disregarding the reactions of these three unstable differential varieties.

Chester (2) first proposed this group concept and Johnston (3) later concurred; however, the currently used nomenclature is based on Basile's Unified Numeration (UN) scheme, which keys isolates to UN races (1). The 183 physiologic races included in the Sixth Revision of the International Register (4) can be grouped into 27 UN races (1).

The one hundred races isolated in the United States from 1926 through 1960 can be grouped into 21 UN races (table 7). Where UN races contain many races, the numbers of the major races (those most frequently isolated) are italicized. These major races account for most of the isolates, as shown by the number and percentage of total isolates.

As with the originally recognized standard physiologic races, changes in prevalence of UN races can be presented as percentages of total isolates during successive 5-year periods (fig. 2). Changes in prevalence of UN races can be followed similarly to changes in standard races.

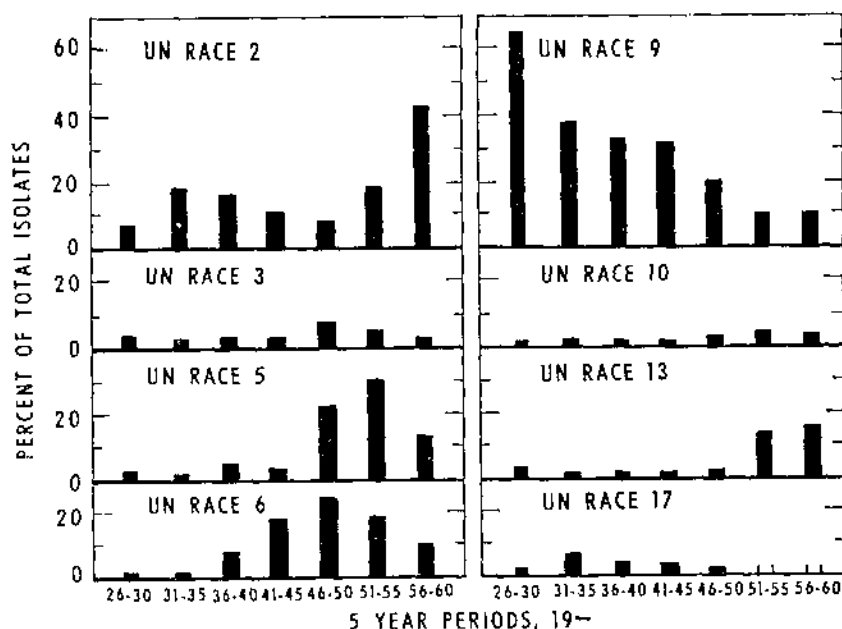


FIGURE 2.—Percentage of total isolates represented by 8 United Numeration (UN) races of *Puccinia recondita* F. sp. *tritici* in the United States in successive 5-year periods from 1926 through 1960.

TABLE 7.—*Number of isolates and percentage of total isolates represented by 21 Unified Numeration (UN) races of Puccinia recondita f. sp. tritici identified from collections analyzed in the United States from 1926 through 1960*

UN race	United States races included ^{1,2}	Number of isolates of ³ —		Percentage of total isolates of—	
		All races	Major races	All races ⁴	Major races
1	<i>1, 16, 53, 120, 123</i> -----	95	77	0.6	0.5
2	<i>2, 15, 25, 34, 127</i> -----	3,594	3,586	22.3	22.3
3	<i>3, 12, 32, 44, 53, 61, 78, 84, 102, 111, 161</i> -----	1,148	1,096	7.1	6.8
4	<i>4</i> -----	2	-----	(⁵)	-----
5	<i>5, 52, 100</i> -----	2,835	2,884	17.9	17.9
6	<i>6, 23, 39, 40, 53, 103, 105, 128</i> -----	2,653	2,592	16.5	16.1
7	<i>7, 60</i> -----	20	-----	0.1	-----
8	<i>48</i> -----	1	-----	(⁵)	-----
9	<i>9, 10, 13, 19, 20, 29, 31, 108</i> -----	2,762	2,754	17.2	17.1
10	<i>11, 14, 26, 38, 74, 131</i> -----	499	491	3.1	3.1
11	<i>17, 36, 93</i> -----	156	143	1.0	0.9
12	<i>18, 68, 106</i> -----	9	-----	0.05	-----
13	<i>21, 30, 35, 42, 54, 65, 77, 80, 82, 101, 104, 112, 113, 114, 115, 122, 130</i> -----	1,717	1,606	10.6	10.0
14	<i>37, 43, 49, 50, 64, 69, 110, 123</i> -----	298	269	1.8	1.7
15	<i>27, 41, 117</i> -----	9	-----	0.05	-----
16	<i>33, 46, 51, 79</i> -----	61	37	0.4	0.2
17	<i>45, 57, 70, 81, 88, 90, 140, 143</i> -----	215	192	1.3	1.2
18	<i>47</i> -----	2	-----	(⁵)	-----
19	<i>55</i> -----	21	-----	0.1	-----
20	<i>56</i> -----	5	-----	0.03	-----
21	<i>120</i> -----	1	-----	(⁵)	-----

¹ Only races identified in these studies are included.² More frequently isolated races (major races) are in italics.³ Total isolates of all races—16,153; major races—15,727.⁴ Because of rounding, total for this column is greater than one hundred.⁵ Trace.

SUMMARY

Studies of prevalence and distribution of physiologic races of *Puccinia recondita* f. sp. *tritici* in the United States from 1926 through 1960 were conducted at Lafayette, Ind., and Manhattan, Kans. Collections were cultured in the greenhouse and purified by a single pustule isolation method, and these isolates were tested for pathogenicity to the International Standard differential varieties. This bulletin presents data summaries of these analyses. The number of viable collections varied from year to year, but generally increased over the period. A total of 16,153 isolates from 5,166 collections were studied and one hundred different races were identified. However, a large number of the total isolates represented only a few of the one hundred races identified.

A summary of the data by years shows changes in the prevalence in major physiologic races. Race 9 was the most prevalent race from the beginning of the studies until 1948. Race 5 was the most prevalent from 1949 until 1956. Race 15 has been a very prevalent race for many years. All three of these races were isolated nearly every year during these studies. Races 58, 105, and 122 have been prevalent since about 1945, and have alternately increased and decreased in prevalence since then.

Differences in prevalence of physiologic races in different geographic areas were evident. Races 1 and 11 were the most prevalent races in collections from the western, white wheat area but were not prevalent in other areas. Race 5 was prevalent in all areas except in the western area, but was particularly prevalent in the southeastern, soft red winter wheat area. Race 122 later was similarly prevalent. Races 9 and 15 were particularly prevalent in the central, hard red winter and the north central, hard red spring wheat areas.

The races identified on the International Standard differentials have been grouped into "Unified Numeration" (UN) races according to Basile's key by disregarding the reactions of the unstable differential varieties Carina, Brevit, and Hussar. Twenty-one UN races were recognized among the one hundred physiologic races identified in these studies. Changes in prevalence can be followed with UN races as with the standard races.

LITERATURE CITED

- (1) BASHLE, RITA.
1957. A DIAGNOSTIC KEY FOR THE IDENTIFICATION OF PHYSIOLOGIC RACES OF *PUCCINIA RUBIGO-VERA TRITICI* GROUPED ACCORDING TO A UNIFIED NUMERATION SCHEME. U.S. Dept. Agr. Plant Dis. Rptr. 41: 508-511.
- (2) CHESTER, K. S.
1946. THE NATURE AND PREVENTION OF THE CEREAL RUSTS AS EXEMPLIFIED IN THE LEAF RUST OF WHEAT. *Chimica Botanica*. 269 pp. Waltham, Mass.
- (3) JOHNSTON, C. O.
1956. UNIFIED NUMBERS FOR RACES OF *PUCCINIA TRITICINA*. *Robigo* 1: 2.
- (4) ———
1961. SIXTH REVISION OF THE INTERNATIONAL REGISTER OF PHYSIOLOGIC RACES OF *PUCCINIA RECONDITA* ROB. EX DESM. (FORMERLY *P. RUBIGO-VERA TRITICI*). U.S. Dept. Agr., Agr. Res. Serv., ARS 31-27, 15 pp.
- (5) ——— and LEVINE, M. N.
1955. FIFTH REVISION OF THE INTERNATIONAL REGISTER OF PHYSIOLOGIC RACES OF *PUCCINIA RUBIGO-VERA* (DC.) WINT. P. SP. *TRITICI* (ERIKS.) CARLETON-*(P. TRITICINA* ERIKSS.). U.S. Dept. Agr. Plant Dis. Rptr. Sup. 233, 17 pp.
- (6) ——— and MAINS, E. B.
1932. STUDIES ON PHYSIOLOGIC SPECIALIZATION IN *PUCCINIA TRITICINA*. U.S. Dept. Agr. Tech. Bul. 313, 22 pp.
- (7) MAINS, E. B. and JACKSON, H. S.
1926. PHYSIOLOGIC SPECIALIZATION IN THE LEAF RUST OF WHEAT, *PUCCINIA TRITICINA* ERIKSS. *Phytopathology* 16: 83-120.
- (8) WILLIAMS, ERVIN, JR., and JOHNSTON, C. O.
1965. EFFECT OF CERTAIN TEMPERATURES ON IDENTIFICATION OF PHYSIOLOGIC RACES OF *PUCCINIA RECONDITA* P. SP. *TRITICI*. *Phytopathology* 55: 1317-1319.

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