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PHYSIOLOGIC SPECIALIZATION IN PUCCINIA CORONATA AVENAE (CORDA) ERIKS. AND HENN.

By

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PHYSIOLOGIC SPECIALIZATION IN PUCCINIA CORONATA AVENAE (CORDA) ERIKS. AND HENN.

INTRODUCTION

The presence of physiologic specialization in the rusts was first demonstrated in 1894 by Eriksson and Henning (29), and since that time many rusts have been shown to consist of two or more entities, each having a specific host relationship. Two developments have come about in our understanding of these specialized entities, first that major physiologic units exist within such species of rust as *Puccinia graminis* Pers. and *P. coronata* Corda and are distinguished by their ability to infect certain host species; second, that there are minor units which are separated by their specific reaction on varieties. The former are considered as physiologic varieties and the latter as physiologic forms.

In the present investigation an attempt has been made to identify, and determine the prevalence and distribution of physiologic forms of *P. coronata avenae* (Corda) Eriks. and Henn. present in the oat-growing regions of the United States and Canada during the years 1927, 1928, 1929, and 1930. The relationship of the occurrence of these forms to the specific host from which they were collected, and the host ranges of the most important forms has also been studied.

PERTINENT LITERATURE

Our knowledge of physiologic specialization in the rust fungi begins with Schroeter (59). In 1879 he calls attention to the presence of physiologic variation in certain rusts on Carex. Similar variation in *Puccinia graminis* Pers. and other rust fungi were reported by Dietel (18), in 1887. It remained for Eriksson and Henning (29) in 1894 to first definitely demonstrate physiologic specialization based on pathogenicity. They showed that there were present within *Puccinia coronata* Corda at least four physiologic varieties and within *P. dispersa* Eriks. two such varieties, which were distinguished by their ability to infect certain hosts. Later in the same year Eriksson (24) described six physiologic varieties in *P. coronata*; four in *P. dispersa*; five in *P. graminis*, and five in *P. glumarum* (Schm.) Eriks. and Henn. Three physiologic varieties were added to *P. coronata* by Klebahn (41, 42, 43) and three by Eriksson (25, 28), while Muhlethaler (49), using a different host relationship as the basis of his classification, described twelve physiologic varieties. Eriksson (26) later added two physiologic varieties to *P. dispersa* and raised all of these to specific rank. One physiologic variety was added to *P. graminis* by Eriksson (27) and three by Jaczewski (36), while in the United States Stakman and Piemeisel (65) have added the physiologic variety *P. graminis tritici compacti* and suggest the establishment of _P. phlei-pratensis_ Eriks. and Henn. as an additional variety under _P. graminis_. This same phenomenon has been observed and studied in many additional species of rust by Magnus (44), Rostrup (57), Klebahn (42), Dietel (19), Ward (68), Bandi (9), Probst (56), Jordi (37, 38), and others.

That it is possible to further divide certain of these physiologic varieties described by Eriksson and Henning (29), Eriksson (24), Klebahn (42), and others, into physiologic forms distinguished by their specific reaction on varieties or species, was first shown by Stakman and Piemeisel (65). Working with the physiologic variety _Puccinia graminis tritici_ Eriks. and Henn., Stakman and Levine (62) were able to distinguish 37 physiologic forms on the basis of the differential reaction of 12 varieties of wheat. The existence of four physiologic forms within _P. graminis avenae_ Eriks. and Henn. was demonstrated by Stakman, Levine and Bailey (63). Later Bailey (8) described a fifth form, and in 1928 Gordon (31) and Gordon and Bailey (32) reported a sixth physiologic form occurring in Canada.

The presence of physiologic forms within the rust species is not limited to _P. graminis_. Mains and Jackson (46) were able to distinguish 12 physiologic forms of _P. triticina_ Eriks. by their specific reaction on 11 varieties of wheat. Scheibe (58) working in Germany discovered four forms of _P. triticina_, one of these being similar to one described by Mains and Jackson.

Mains (45) reports the presence of two physiologic forms in _P. dispersa_, two in _P. anomala_ Rostr., and four in _P. sorghi_ Schw. Stakman and Christensen (60) earlier reported the presence of three and possibly five physiologic forms of _P. sorghi_. Later Stakman, Christensen and Brewbaker (61) recognized seven physiologic forms of _P. sorghi_ by their specific reaction on eight selfed lines of corn. Hungerford and Owens (35) reported indication of the presence of two or more specialized forms of _P. glumarum tritici_ Eriks. and Henn. Bailey (7) demonstrated the presence of at least three, and possibly four, forms of _P. helianthi_ Schw.

It is clear that with the increase in our knowledge of physiological specialization, at least in _P. graminis_, we have gone from a rather wide grouping as proposed by Eriksson and Henning (29), Eriksson (24), and others to a more narrow grouping as set out by Stakman and Piemeisel (65). The work that has been done on _P. coronata_ seems to tend in the same course. The development of our knowledge of specialization in this species begins with de Bary (11), when he discovered in 1865 that the aecial stage of _P. coronata_ occurred on _Rhamnus cathartica_ L. and _R. frangula_ L. Nielsen (52) in 1877 secured infection on _Lolium perenne_ L. with aeciospores from _Rhamnus cathartica_ and in turn infected oats with the urediniospores from _Lolium perenne_. Then Cornu (13) in 1880 infected oats directly with aeciospores from *Rhamnus cathartica*. Plowright (54) in 1889 suggested the presence of two species within *Puccinia coronata*. His conclusions were based mainly upon the fact that teliospores from *Lolium perenne* would not infect *Rhamnus frangula*, while teliospores from *Dactylis glomerata* L. and *Festuca sylvatica* Vill. readily produced aecia on *Rhamnus frangula*. Klebahn (39) reported in 1892 that there were two species of crown rust. That species which bore teliospores on *Dactylis glomerata*, *Festuca sylvatica* and other grasses, and bore aeciospores on *Rhamnus frangula*, he called *Puccinia coronata*. While the species which produced teliospores on *Lolium perenne*, *Avena sativa* L., *Festuca elatior* L., *Arrhenatherum elatius* (L.) Beauv. and other grasses, and produced aeciospores on *Rhamnus cathartica* and other Rhamnus species, he called *Puccinia coronifera* Klebahn. The conclusions of Klebahn were supported in later investigations by Klebahn (40, 41, 42), Eriksson (25, 28), Eriksson and Henning (30), and Muhlethaler (49).

Eriksson and Henning (29) were probably the first to recognize the presence of physiologic varieties in crown rust. They divided *Puccinia coronata* into three series and certain of these were subdivided into "Formen". Series I, with aecial stage on *Rhamnus cathartica* (*Puccinia coronifera* Kleb.), was divided into two "Formen": *Avenae* and *Alopecuri*; series II, with aecial stage on *R. frangula* (*Puccinia coronata* Kleb.), consisted of one "Formen" occurring on Dactylis glomerata and Festuca silvatica; and series III, an aecial stage on Rhamnus dahurica (Puccinia coronata var. himalensis Barcl.), consisted of one "Formen". Two physiologic varieties Calamagrostidis and Melica were not included in the series because their aecial stage was unknown. Later Eriksson (24) divided crown rust into four series and certain of these series were subdivided into "forme species." Series I (Puccinia coronifera Kleb.) was divided into four "forme species": Avenae, Alopecuri, Festucae, and Lolii; series II (P. coronata (Corda) Kleb.) contained only one "forme species": Calamagrostis; series III (P. coronata var. himalensis Barcl.) contained no "forme species"; and series IV (aecial stage unknown) contained one "forme species": Melicae. Additional "forme species" were added to series I and II by Klebahn (42) and Eriksson (25). In 1911 Muhlethaler (49) presented a somewhat different arrangement. He divided crown rust into five series: I. P. coronifera Kleb.; II. P. himalensis (Barcl.) Diet.; III. P. Alpinae-coronata nov. sp.; IV. P. coronata (Corda) Kleb.; V. P. coronata Corda s. lat. Series I contained nine "forme species", series IV three "forme species", series IV three "forme species", and series V one "forme species."

Treboux (65), working with crown rust in southern Russia, did not secure the differential reaction on Rhamnus species reported by Klebahn (42), Eriksson (24), and Muhlethaler (49). Using aeciospores secured from R. frangula he was able to infect Avena sativa, a host belonging to P. coronifera Kleb., and using aeciospores secured from Rhamnus cathartica he was able to infect Agrostis stolonifera, Calamagrostis arundinacea, and Phalaris arundinacea, all of which are hosts of Puccinia coronata (Corda) Kleb. Treboux (66) concluded that the existence of separate species of crown rust upon either Rhamnus cathartica or R. frangula is doubtful.

In the United States, Arthur and Fromme (5), Arthur and Holway (6), Carleton (12), Melhus, Dietz and Willey (47), Melhus and Durrell (48), Dietz (21), and others prefer to retain the name Puccinia coronata Corda. The marked differentiation on Rhamnus species reported by Klebahn (41) has not been reported in America. Arthur and Holway (6) were able to produce infection on Avena sativa using aeciospores secured from Rhamnus lanceolata. Carleton (12) used aeciospores produced on R. lanceolata and produced infection on Phalaris caroliniana. The host range of Puccinia coronata has been extended, both on the alternate hosts and on the gramineous hosts, by Arthur (2, 3, 4), Melhus and Durrell (48), Melhus, Dietz and Willey (47), and Dietz (21). Melhus, Dietz and Willey (47) using teliospores produced on Avena sativa were able to secure pycnia on Rhamnus frangula.

Dietz (21) secured normal aecia on R. dahurica using teliospores produced on Avena sativa. The results secured by investigators in the United States do not justify the division of crown rust into the various species reported in Europe by Klebahn (39), Eriksson (24), and Muhlethaler (49).

Melhus, Dietz and Willey (47) studied four "biologic forms" (physiologic varieties) of crown rust: P. coronata avenae, P. coronata lolii, P. coronata calamagrostis, and P. coronata holci. They determined the reaction of various gramineous species to each of these physiologic varieties. The gramineous host ranges of these four physiologic varieties overlap somewhat, but the reaction of each host was specific for each physiologic variety.

Dietz (21) found that the alternate host range of crown rust was not limited to the genus Rhamnus, or to the family Rhamnaceae. He secured aecial infection of crown rust on Berchemia scandens (Hill) Trel. of the family Rhamnaceae, and Lepargyrea canadensis of the family Eleagnaceae, in addition to thirteen species of Rhamnus. Dietz (21) secured a marked specialization in reaction on the alternate hosts with different varieties of crown rust. This specialization of varieties and the wide alternate host range of crown rust is further evidence, Dietz believes, that the crown rust organism should be considered as one species.

Hoerner (34) was the first to report the presence of physiologic specialization within the variety _P. coronata avenae._ He distinguished four physiologic forms on the basis of their reaction on Iowa 73 (Ruakura) and Iowa 96 (Green Russian):

Form 1. infects both varieties normally.
Form 2. infects both varieties weakly.
Form 3. infects Iowa 73 weakly and Iowa 96 normally.
Form 4. infects Iowa 73 normally and Iowa 96 weakly.

Popp (55) identified 22 cultures of _P. coronata avenae_ collected from five provinces of Canada. Using Iowa 96 (Green Russian), Sterilis Selection, and Minnesota 539 (White Russian) as differential hosts, he was able to distinguish four physiologic forms as follows:

Form 1. (Eight cultures) infects Sterilis Selection weakly; Minnesota 539 (White Russian) normally, and Iowa 96 (Green Russian) normally.
Form 2. (Eight cultures) infects all three varieties weakly.
Form 3. (Two cultures) infects Sterilis Selection normally; Minnesota 539 (White Russian) weakly, and Iowa 96 (Green Russian) weakly.
Form 4. (Four cultures) infects all varieties more or less normally.

Parson (53) obtained 15 collections of crown rust from the United States and Canada. Using four varieties as differential hosts, he was able to distinguish five physiologic forms as follows:

Ruakura - resistant (Hoerner's Form 3)
  Avena sterilis nigra - resistant . . . . form 3
  A. sterilis nigra - susceptible . . . .
    Red Rustproof - resistant . . . . form 5
    Red Rustproof - susceptible. . . . . form 4
Ruakura - susceptible (Hoerner's Form 1)
  Green Mountain - resistant . . . . form 2
  Green Mountain - susceptible . . . . form 1

Parson determined the reaction of each of his forms on 27 varieties, selections, and species of oats, and found that none were resistant to more than three physiologic forms.

Murphy (50) secured 45 collections of *Puccinia coronata avenae*, of which 32 were collected on Avena and 13 on Rhamnus. An equal number of cultures isolated from these collections were each tested on pure line selections of 33 varieties and species of oats. Eight of these acting as differential hosts disclosed the following nine physiologic forms:

Belar - resistant
  Red Rustproof (C.I. 1079[1]) - resistant
    College Algerian (C.I. 2052) - resistant . . . form 3
    College Algerian (C.I. 2052) - susceptible . . form 8
  Red Rustproof (C.I. 1079) - susceptible
    Cowra - resistant. . . . . form 9
    Cowra - susceptible. . . . . form 7
Belar - susceptible
  Iowa No. 69 - resistant
    Avena strigosa - resistant
      Anthony (C.I. 2143) - resistant . . . . form 4
      Anthony (C.I. 2143) - susceptible . . . . . . form 2
    Avena strigosa - susceptible
  Iowa No. 69 - susceptible
    Iowa No. 102 - resistant . . . . form 6
    Iowa No. 102 - susceptible . . . . form 5

The 13 aecial collections on five species of Rhamnus were identified as follows: four collections on *Rhamnus cathartica* were form 3; six collections on *R. lanceolata* were form 5; one each from *R. tinctoria*, *R. spp.* (from Montana), and *R. infectoria* were forms 7, 8, and 9, respectively.

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[1] C.I. = Bureau of Plant Industry, Cereal Investigation accession number.

MATERIAL AND METHODS

Leaves infected with *Puccinia coronata avenae* were collected on naturally infected oat plants and on Rhamnus naturally and artificially infected, during the years 1927, 1928, 1929, and 1930. For each collection, the name of collector, date, place, and the name of the host were recorded. During transit, crown rust spores retain their viability much longer when the infected leaves are allowed to dry immediately after collection and are placed in an ordinary manila envelop. Aecial collections, due to their short viability, were immediately used to infect oat plants, and the resulting uredinial stage continued, or the infected leaves stored in the refrigerator. All cultures were maintained on the variety Iomine (C.I. 2827) during 1928. However, this variety showed partial resistance to certain forms and Markton (C.I. 2053) was substituted for it during 1929 and 1930.

Single uredinium cultures were isolated by inoculating Markton or Iomine plants sparsely with spores from a particular collection. About six or seven days after inoculation and before any uredinia had broken through the epidermis, a plant was selected which bore a single uredinium. This plant was then placed under a covered lamp chimney (Plate I, fig. 2) and the urediniospores allowed to mature. Because of the possibility of the presence of more than one physiologic form in a collection, two single-uredinial isolations were usually made from each collection. Each culture had as its source a single uredinium.

Seedling plants were usually inoculated between 4 and 6 p.m. The first leaf of each plant was gently drawn between the moistened forefinger and thumb, then the entire plant was moistened with a constant-pressure sprayer. The plants were then moved to the room containing the stock cultures and each plant was individually inoculated with the desired culture by applying a small amount of crown rust spores to the moistened surface of the first leaf with a flattened needle. The plants were again sprayed and placed in a moist inoculation chamber where they were kept for approximately 14 hours. In order that the plants might not dry too quickly or otherwise become injured, the chambers were opened at about 8 a.m. and the plant retained in the open chamber until about 4 p.m.

Where types of infection were to be determined, the plants were placed in muslin compartments (Plate I, fig. 1) similar to those described by Melhus, Dietz and Willey (47); while those used for stock cultures were held under lamp chimneys. The tops of the chimneys were covered with a thin layer of cotton held between two pieces of cheese-cloth and this all fastened with a rubber band (Plate I, fig. 2). Each lamp chimney would cover the contents of a three-inch flower pot. These pots were variety used as a differential host by Parson (53).

At the beginning of the investigation, approximately 200 varieties, selections, and species, reported as being resistant to crown rust, were inoculated with ten cultures which furnished a basis for the selection of possible differential hosts. From these investigations, a set of 33 differential hosts was selected. This preliminary study gave evidence that certain of the commercial varieties and so-called pure-line selections on hand were not homozygous for reaction to all crown rust cultures. Because of this heterozygous reaction, a single-panicle selection was made of each of the possible differential hosts at the beginning of the experiment. Unless otherwise stated, pure-line selections were used throughout these investigations for differentiating physiologic forms.

The differential hosts were inoculated with each culture of crown rust. When pure lines were used as possible differential hosts, five plants of each were inoculated and their reaction recorded. Ten or more plants were inoculated when the possible differential host was not a pure line. Whenever a variety of species appeared heterozygous for resistance to a particular culture, a larger number of plants were inoculated and the predominating reaction recorded.

Types of Crown Rust Infection

In recording the reaction of different varieties, selections, and species to crown rust, it was necessary to adopt a series of rust manifestations which would describe the classes of host reactions observed. The types of crown rust infection observed are shown in Plate II, fig. 2, and a description follows:

Immune	I.	- No macroscopic evidence of infection.
Completely resistant	0.	- No uredinia formed, necrotic areas present.
Highly resistant	1.	- Uredinia few, small, always in necrotic areas, also more or less necrotic areas produced without the development of uredinia.
Moderately resistant	2.	- Uredinia fairly abundant, small to medium size, always in necrotic or very chlorotic areas.
Moderately susceptible	3.	- Uredinia abundant, medium in size, and surrounded by chlorotic areas.
Completely susceptible	4.	- Uredinia abundant, large, no necrosis or chlorosis immediately surrounding the uredinia.

The reaction of all plants to crown rust was recorded 10 and 14 days after inoculation. During the interval between the time of inoculation and recording, the plants were kept under optimum conditions for the normal development of the oat plants. The type of infection on a particular pure line inoculated with a particular physiologic form is quite constant when environmental conditions are uniform and favorable. During cloudy weather, artificial light is necessary in order to secure normal types of infection. A "green-island" type of infection may be developed on a completely susceptible plant by reducing the light intensity for a period of two days. Excessive drought, wilting, excessive high or low temperature, and abnormal nutrition also tend to produce subnormal types of infection.

In the present investigation, a difference of at least two types of infection was considered necessary to establish a new form, that is, a type 0 contrasted with a type 2, a type 1 with a type 3, or a type 2 with a type 4. It was unusual for the reaction of a pure line to a particular physiologic form to vary more than one type under normal greenhouse conditions.

Field Test of Varieties and Selections

A knowledge of the field reaction of varieties studied under greenhouse conditions is very desirable. This is especially true of those varieties used as differential hosts, and of those additional varieties used in determining the host range of a particular physiologic form. During 1926, 1927, and 1928, a uniform oat crown-rust nursery was grown at Ames, Iowa, and Experiment, Georgia. This uniform nursery contained pure-line selections of 100 varieties which were selected for their known reaction to crown rust. During 1929 a new uniform oat crown-rust nursery containing pure-line selections of 100 varieties, species, and selections was grown at eight different experiment stations in the central and southern portions of the United States. The locations of these nurseries and the names of the cooperators were as follows:

Location	Cooperator
Ames, Iowa	----
Knoxville, Tennessee	S.H. Essary
Experiment, Georgia	R.P. Bledsoe
Tifton, Georgia	W.J. Davis
A. & M. College, Mississippi	L.E. Miles
Denton, Texas	P.B. Dunkle
Stillwater, Oklahoma	J.C. Ireland
Manhattan, Kansas	J.H. Parker and C.O. Johnston

During 1929, 660 additional varieties, selections, and species were grown at Manhattan, Kansas, and Ames, Iowa. Three hundred of these were introduced foreign varieties supplied by T.R. Stanton, Office of Cereal Crops and Diseases, Bureau of Plant Industry, Washington, D.C.

The percentages of crown rust infection on the different pure lines, varieties, selections, and species included in the oat crown-rust nurseries were determined according to the scale illustrated by Durrell and Parker (23). Types of crown rust are often very difficult to determine under field conditions, because of the maturity of the oat plant and the presence of uredinia in different stages of development. Whenever a variation was observed, the range from the most resistant to the most susceptible was recorded.

IDENTIFICATION OF PHYSIOLOGIC FORMS

One hundred seventy-one collections of *Puccinia coronata avenae* were secured during 1927, 1928, 1929, and 1930, on varieties and species of Avena, and species of Rhamnus. Two hundred forty-five rust cultures were isolated from these collections. The distribution of these collections according to the time and the state or province from which they were collected is given in table 1.

Table 1. Distribution of collections of *Puccinia coronata avenae* during 1927, 1928, 1929, and 1930, in states and provinces.

State or Province	Number of collections				Total collections
	1927	1928	1929	1930	
Alabama			1		1
California		5			5
Florida		1		12	13
Georgia		4	4		8
Illinois	1				1
Iowa	2	16	29	21	68
Kansas	2		10		12
Minnesota			2		2
Mississippi		4	4		8
Missouri	1	1	4		6
Nebraska		1			1
North Dakota	1	1	1		3
Ohio		1			1
Oklahoma	1	1	3		5
Ontario		1			1
Oregon		1	3		4
Quebec	1				1
South Dakota			1		1
Tennessee		1	6		7
Texas	1	6	4		11
Virginia			3		3
West Virginia		1	8		9
Total	10*	45	83	33	171

*Nine collections secured in 1927 were furnished by Mr. L.D. Leach, who made a preliminary study of physiologic specialization and identified three physiologic forms (unpublished data).

The number of collections secured on different hosts during the years 1927, 1928, 1929, and 1930 is given in table 2.

Table 2. Host and number of collections of crown rust secured during 1927, 1928, 1929, and 1930.

Host	Number collections			
	1927	1928	1929	1930
Avena species	10	32	66	12
Rhamnus cathartica	-	4	1	5
" chlorophora	-	-	-	2
" infectoria	-	1	13	5
" lanceolata	-	6	-	2
" montana	-	1	3	3
" tinctoria	-	1	-	4
Total	10	45	83	33

All the collections on Rhamnus species were from artificially inoculated plants, except one on Rhamnus lanceolata secured during 1928, and three on Rhamnus cathartica (two during 1928 and one during 1929). The collections on Avena species were all taken from naturally infected plants in the field.

Cultures Collected During 1927 and 1928

Fifty-five cultures of crown rust were isolated from an equal number of collections taken during 1927 and 1928. A uniform set of 33 pure lines, selected from different varieties, selections, and species of oats was separately inoculated with each of these cultures. Nine physiologic forms were identified among these 55 cultures by the differential reaction of eight of the 33 pure lines. In table 3 is given the name of each of the 33 pure-line-selected: varieties, selections, and species, used as possible differential hosts, and the average type of

Table 3. Reaction of 33 pure-line selections to the nine physiologic forms of *Puccinia coronata avenae* identified from collections made during 1927 and 1928.

Pure-line selections of: varieties, selections, and species	Average type of infection with physiologic form number: 1	2	3	4	5	6	7	8	9
Belar (C.I. 2760)	4	4	0	3	4	3	0	0	1
Red Rustproof (C.I. 1079)	4	4	0	3	4	4	4	1	4
College Algerian (C.I. 2052)	4	4	0	4	4	4	4	4	4
Cowra (C.I. 2761)	4	3	0	3	4	4	3	0	1
Iowa 69 (C.I. 2463)	0	0	4	0	4	4	4	4	4
Avena strigosa (C.I. 1782)	4	2	0	0	3	3	4	3	4
Anthony (C.I. 2143)	0	4	4	0	4	4	4	4	4
Iowa 102 (C.I. 2464)	0	4	4	0	4	0	4	4	4
Avena brevis (C.I. 2762)	4	1	4	1	4	4	4	4	4
Red Rustproof (C.I. 775)	4	4	4	4	4	4	4	4	4
Sunrise (C.I. 982)	4	1	0	2	4	3	2	1	4
Black Algerian (C.I. 204)	4	3	1	4	4	4	2	0	3
Nortex (C.I. 2382)	4	4	0	4	4	4	4	4	4
Ruakura (C.I. 2052)	3	4	1	4	4	4	4	1	0
Early Burt (C.I. 2763)	4	3	0	4	4	4	2	4	4
Red Rustproof (C.I. 1805)	4	4	0	4	4	4	4	4	4
Green Mountain (C.I. 1892)	0	1	4	0	4	4	4	4	4
Fulghum (C.I. 650-203)	4	4	4	4	4	4	4	4	4
Burt (C.I. 2054)	4	4	4	4	4	4	4	4	4
White Tartar (C.I. 1640)	4	4	4	4	4	4	4	4	4
Red Rustproof (C.I. 1640)	4	4	0	4	4	4	4	4	4
Green Russian (C.I. 1978)	4	4	4	4	4	4	4	4	4
Iowa 46	0	1	4	0	4	4	4	4	4
Iowa 77 (C.I. 2813)	0	4	4	1	4	1	4	4	4
Iomine (C.I. 2827)	4	3	4	4	4	4	3	3	4
Hundred Bushel (C.I. 2797)	4	3	1	4	4	4	4	4	4

Table 3. Concluded.

Pure-line selections of varieties, selections, and species	Average type of infection with physiologic form number: 1	2	3	4	5	6	7	8	9
Early May (C.I. 2828)	4	4	1	4	4	4	4	4	4
D.A.C. No. 10 (C.I. 2829)	4	4	2	4	4	4	4	3	4
Guyra (C.I. 2768)	4	4	3	4	4	4	3	3	3
Warrigal (C.I. 2798)	3	3	1	3	4	3	3	2	3
Sidney (93)	4	4	1	4	4	4	4	4	1
Golden (C.I. 2806)	4	4	4	4	4	4	3	3	3
Mortgage Lifter (C.I. 2804)	4	4	3	4	4	4	4	3	4

infection of each to the nine identified physiologic forms.

The nine physiologic forms discovered during 1927 and 1928 may be identified by arranging the first eight pure lines in table 3 in a dichotomous key (50).

Cultures Collected During 1929 and 1930

The first 17 pure-line-selected: varieties, selections, and species given in table 3 were retained as possible differential hosts for use during 1929 and 1930. Eight additional pure lines, seven varieties, and one species were added. Two of the foreign varieties, "Avena victoria" (C.I. 2764), and "Avena capa" (C.I. 2765), were obtained from Mr. Jose M. Scasso of Moron, Argentina, while "Avena 1095a" (C.I. 2766) and "Avena 64s" (C.I. 2767) were obtained from Doctor Alberto Boerger, Senior Director del Instituto Fitotecnico, Departmento Colonia, Uruguay. These four varieties were reported resistant to crown rust by Mr. Scasso*. The other three varieties Hay (C.I. 1622), Schoolmam (C.I. 2057), and Victoria (C.I. 2401) were included because of their unusual resistance during a natural epiphytotic of crown rust in the summer of 1929 at Ames, Iowa, and Manhattan, Kansas. Avena strigosa glaberscens (C.I. 2630) was apparently immune during the same epiphytotic at both stations.

*These varieties were reported as being resistant to crown rust in Argentine, by Mr. Scasso, in a personal letter to the writer dated April 20, 1929.

One hundred ninety cultures of crown rust were isolated from 116 collections during 1929 and the spring of 1930. Uniform groups of 25 pure lines, seven varieties and one species of oats were inoculated separately with each of these cultures and eight physiologic forms were identified. Four of these were forms previously identified in collections secured during 1927 and 1928, and four were first isolated in 1929.

In table 4 is given the reaction of pure lines, numbers 1 to 17, to physiologic forms numbers 1, 3, 5, 6, 10, 11, 12, and 13 collected during the years 1927, 1928, 1929, and 1930, and the reaction of pure lines, varieties, and species, numbers 18 to 33, for the same physiologic forms collected during 1929 and 1930. As physiologic forms 2, 4, 7, 8, and 9 were not recovered during 1929 and 1930, the reaction of only pure lines numbers 1 to 17 is recorded.

Table 4. Reaction of 33 pure-line selections, varieties, and species to 13 physiologic forms of Puccinia coronata avenae identified during 1927, 1928, 1929, and 1930.

	Number and name of pure-line selections, varieties, and species	Average type of infection with physiologic form number:												
		1	2	3	4	5	6	7	8	9	10	11	12	13
	Pure-line selections													
1	Belar (C.I. 2760)	4	4	0	3	4	3	0	0	1	0	4	0	1
2	Red Rustproof (C.I. 1079)	4	4	0	4	4	4	4	1	4	0	4	0	1
3	College Algerian (C.I. 2052)	4	4	0	4	4	4	4	4	4	0	4	0	0
4	Cowra (C.I. 2761)	4	3	0	3	4	4	3	0	1	0	4	0	1
5	Iowa 69 (C.I. 2463)	0	0	4	0	4	4	4	4	4	0	0	0	1
6	Avena strigosa (C.I. 1782)	4	2	0	0	3	3	4	3	4	4	4	4	4
7	Anthony (C.I. 2143)	0	4	4	0	4	4	4	4	4	0	0	0	1
8	Iowa 102 (C.I. 2464)	0	4	4	0	4	0	4	4	4	0	4	0	4
9	Avena brevis (C.I. 2762)	4	1	4	1	4	4	4	4	4	4	4	4	4
10	Red Rustproof (C.I. 775)	4	4	4	4	4	4	4	4	4	4	4	4	4
11	Sunrise (C.I. 982)	4	1	0	2	4	3	2	1	4	0	4	0	1
12	Black Algerian (C.I. 204)	4	3	1	4	4	4	2	0	3	0	4	0	0
13	Nortex (C.I. 2382)	4	4	0	4	4	4	4	4	4	0	4	0	0
14	Ruakura (C.I. 2025)	4	4	0	4	4	4	4	1	0	1	0	0	0
15	Early Burt (C.I. 2763)	4	3	0	4	4	4	2	4	4	0	4	0	0
16	Red Rustpfoof (C.I. 1805)	4	4	0	4	4	4	4	4	4	0	4	0	1
17	Green Mountain (C.I. 1892)	0	1	4	0	4	4	4	4	4	1	1	0	1
18	Bathurst (C.I. 1810)	4		0		4	4				0	4	0	4
19	Glenn Innis (C.I. 980)	4		4		4	4				4	4	4	4
	Varieties													
20	White Russian (C.I. 2460)	0		4		4	0				0	0	0	1
21	White Russian (C.I. 2461)	4		4		4	4				4	4	4	4
22	Green Russian (C.I. 2342)	4		4		4	4				4	4	4	4
23	Green Russian (C.I. 2344)	4		4		4	4				4	4	4	4
24	Avena brevis (C.I. 1783)	0		0		4	4				4	4	4	4
25	Markton (C.I. 2053)	4		4		4	4				4	4	4	4

Table 4. Concluded.

Number and name of pure-line selections, varieties, and species	Average type of infection with physiologic form number: 1	2	3	4	5	6	7	8	9	10	11	12	13
Varieties													
26 Hay (C.I. 1622)	4		4		4	4				4	4	4	4
27 Schoolmam (C.I. 2057)	4		4		4	4				4	4	4	4
28 Victoria (C.I. 2401)	0		0		0	0				I	0	I	0
29 "Avena victoria" (C.I. 2764)	0		0		0	0				I	0	I	0
30 "Avena capa" (C.I. 2765)	3		0		3	4				I	0	0	0
31 "Avena 1095a" (C.I. 2766)	4		0		4	4				0	1	0	0
32 "Avena 64s" (C.I. 2767)	3		0		3	4				0	0	0	0
Species													
33 Avena strigosa glaberscens (C.I. 2630)	0		0		0	0				4	0	I	0

Key for Identification of Physiologic Forms

Thirteen physiologic forms were identified among the 245 cultures studied by using the differential reactions of eight pure lines and one species, *Avena strigosa glaberscens* (C.I. 2630). *A. strigosa glaberscens* (C.I. 2630) was not pure-line selected, however, it always gave a homozygous reaction to physiologic forms 1, 3, 5, 6, 10, 11, 12, and 13. The eight pure-line-selected: varieties, selections, and species; and one species not pure-line-selected, may be arranged in a dichotomous key as follows:

- Belar (C.I. 2760) - resistant
  - Red Rustproof (C.I. 1079) - resistant
    - Iowa 102 (C.I. 2464) - resistant
      - *Avena strigosa glaberscens* (C.I. 2630) - resistant . . . . form 12
      - *Avena strigosa glaberscens* (C.I. 2630) - susceptible . . . . form 10
    - Iowa 102 (C.I. 2464) - susceptible
      - College Algerian (C.I. 2052) - resistant
        - Anthony (C.I. 2143) - resistant . . . . . form 13
        - Anthony (C.I. 2143) - susceptible . . . . form 3
      - College Algerian (C.I. 2052) - susceptible. form 8
  - Red Rustproof (C.I. 1079) - susceptible
    - Cowra (C.I. 2761) - resistant . . . . form 9
    - Cowra (C.I. 2761) - susceptible . . . . form 7
- Belar (C.I. 2760) - susceptible
  - Anthony (C.I. 2143) - resistant
    - *Avena strigosa* (C.I. 1782) - resistant. . . . form 4
    - *Avena strigosa* (C.I. 1782) - susceptible
      - Iowa 102 (C.I. 2464) - resistant. . . . . . form 1
      - Iowa 102 (C.I. 2464) - susceptible. . . . . form 11
  - Anthony (C.I. 2143) - susceptible
    - Iowa 102 (C.I. 2464) - resistant . . . . form 6
    - Iowa 102 (C.I. 2464) - susceptible. . . . . .
      - Iowa 69 (C.I. 2463) - resistant . . . . form 2
      - Iowa 69 (C.I. 2463) - susceptible . . . . . . form 5

Physiologic forms 1, 3, 5, 6, 10, 11, 12, and 13, may be identified by the differential reaction of the pure-line-selected varieties: Belar (C.I. 2760), Anthony (C.I. 2143), Iowa 102 (C.I. 2464); and the species Avena strigosa glaberscens (C.I. 2630). The reaction of each one of these differential hosts along with that of Victoria (C.I. 2401) and a pure-line selection of Markton (C.I. 2053), to each of the eight physiologic forms identified from collections secured during 1929 and 1930 is illustrated in plates III-VI.

Nature of Physiologic Forms Identified

The 13 physiologic forms identified, differ greatly in their ability to infect normally the possible differential hosts given in table 4. A descriptive formula may be given to each form by writing the number (given in table 4, column 1) representing each of the 33 possible differential hosts that show a resistant reaction to it. These formulae would then appear as follows:

Physiologic form number	Formula
1	5, 7, 8, 17, 20, 24, 28, 29, 33.
2	*5, 6, 9, 11, 17.
3	1, 2, 3, 4, 6, 11, 12, 13, 14, 15, 16, 18, 24, 23, 29, 30, 31, 32, 33.
4	*5, 6, 7, 8, 9, 11, 17.
5	28, 29, 33.
6	8, 20, 28, 29, 33.
7	*1, 11, 12, 15.
8	*1, 2, 4, 11, 12, 14.
9	*1, 4, 14.
10	1, 2, 3, 4, 5, 7, 8, 11, 12, 13, 14, 15, 16, 17, 18, 20, 28, 29, 30, 31, 32.
11	5, 7, 14, 17, 20, 28, 29, 30, 31, 32, 33.
12	1, 2, 3, 4, 5, 7, 8, 11, 12, 13, 14, 15, 16, 17, 18, 20, 28, 29, 30, 31, 32, 33.
13	1, 2, 3, 4, 5, 7, 11, 12, 13, 14, 15, 16, 17, 20, 28, 29, 30, 31, 32, 33.

The 13 physiologic forms, as shown by their ability to infect normally the 33 possible differential hosts given in table 4, rank from the most virulent to the least as follows: 5, 6, 9, 7, 1, 11, 2, 8, 4, 3, 13, 10, 12.

Physiologic form 5 is a virulent form. In addition to the possible differential hosts given in tables 3 and 4, approximately 400 additional pure lines, varieties, selections, and species have been inoculated with this form. With the exception of the varieties, Victoria (C.I. 2401) and "Avena victoria" (C.I. 2764), and the species _Avena strigosa glaberscens_ (C.I. 2630), no resistant pure lines, varieties, selections, or species have been found. Form 6, apparently little less virulent than

*These physiologic forms were not identified in collections secured during 1929 and 1930. For that reason their reaction to numbers 18-33 is not known.

form 5, was tested only with the possible differential hosts given in tables 3 and 4.

Physiologic forms 9, 7, 1, 11, 2, 8, and 4 are intermediate in virulence, while forms 3, 13, 10, and 12 are comparatively weak forms. Forms 10 and 12 differ only in reaction on Avena strigosa glaberscens (C.I. 2630).

Under similar conditions, cultures identified as physiologic forms 3, 10, 12, and 13 tended to form teliospores earlier than cultures identified as forms 1, 2, 4, 7, 8, 9, and 11. While cultures identified as forms 5 and 6 rarely showed any teliospore formation. Teliospore formation seems to be characteristic of narrowly specialized forms. It did not seem to be correlated with any particular pure lines, varieties, species, or selections, and it was not limited to plants showing a resistant type of infection. Certain plants with a type 4 infection consistently showed early teliospore formation with certain cultures. However, early teliospore formation occurred more frequently on plants showing a type 1 or type 2 infection. Different cultures belonging to the same physiologic form and growing under similar conditions would sometimes vary greatly in their ability to produce teliospores on certain pure-line selections and varieties. Certain cultures identified as form 12 consistently formed teliospores 10 to 12 days after inoculation on pure-line selections and varieties, numbers: 9, 10, 17, 20, 21, and 26. While other cultures also identified as form 12 did not form teliospores on these same hosts until 21 to 33 days after inoculation. Apparently it would be possible to subdivide certain physiologic forms on the basis of their relative ability to form teliospores on certain hosts.

Plate VII illustrates the relative ability of two cultures to form teliospores. Two panicles of oats were selected, one from Fulghum (C.I. 650-203) and the other from Dookie Agricultural College No. 10 (C.I. 2829). Seed from these panicles were planted at the same time. The resulting seedling plants were inoculated and held under the same conditions until after the photograph in plate VII was secured. Two cultures of crown rust representing forms 3 and 5 were separately inoculated to individual plants from each of the two panicles. Sixteen days after inoculation the culture identified as form 3 had formed abundant telia on both selections, while the culture identified as form 5 had formed only uredinia. The relative ability of these two cultures to form telia was typical of all other cultures identified as forms 3 and 5.

PREVALENCE AND GEOGRAPHIC DISTRIBUTION OF PHYSIOLOGIC FORMS IDENTIFIED

Two hundred forty-five cultures of crown rust were isolated from 171 collections secured during the years 1927, 1928, 1929, and 1930. Each of these was identified as belonging to one of the 13 physiologic forms described in table 4. In table 5 is given the place of collection, name of collector, name of host from which the original collection was secured, and date of this original collection, for each of the 245 cultures identified. This information is grouped according to the physiologic form to which the culture belonged and in order of the date of collection.

Table 5. Source, date of collection and cultures of *Puccinia coronata avenae* identified.

Physiologic form	Place collected	Collector	Host	Date collected
Puccinia coronata avenae Form I	Ames, Ia.	L.D. Leach	Cultivated oats	8-1-27
	Clyde, Kan.	do	Volunteer oats	9-14-27
	Manhattan, Kan.	C.O. Johnson	do	9-18-27
	Stillwater, Okla.	Fred Griffe	do	10-11-27
	College Station, Tex.	P.C. Mangelsdorff	Cultivated oats	2-6-28
	Hollywood, Calif.	J.M. Raeder	Volunteer oats	4-14-28
	Redondo, Calif.	do	do	4-16-28
	San Diego, Calif.	do	do	4-23-28
	San Antonio, Tex.	do	Red Rustproof	5-12-28
	Napa, Calif.	L.D. Leach	Cultivated oats	7-2-28
	Experiment, Ga.	H.C. Murphy	Iomine	5-15-29
	do	do	do	do
	do	do	Sunrise (C.I. 982)	do
	Tifton, Ga.	do	Iomine	5-16-29
	do	do	do	do
	A.& M. College, Miss.	do	Anthony (C.I. 2143)	5-22-29
	do	do	*Avena brevis* (C.I. 1783)	do
	do	do	Sunrise (C.I. 982)	do
	do	do	do	do
	Greenville, Tex.	do	Nortex (C.I. 2382)	5-30-29
	Denton, Tex.	do	Iomine	6-1-29
	do	do	do	do
	Lawton, Okla.	do	Colburt (C.I. 2019)	6-4-29
	Manhattan, Kan.	do	Iomine	6-11-29
	do	do	do	do
	do	do	Anthony (C.I. 2143)	do
	do	do	Sunrise 73	do
	do	do	Rustless (C.I. 724)	do
	Columbus, Kan.	C.O. Johnston	Cultivated oats	6-15-29

Table 5. Continued.

Physiologic form	Place collected	Collector	Host	Date collected
	Columbus, Kan.	C.O. Johnston	Cultivated oats	6-15-29
	Moron, Kan.	do	do	6-16-29
	do	do	do	do
	Parsons, Kan.	do	do	do
	Knoxville, Tenn.	T.R. Stanton	Green Russian (C.I. 2344)	6-19-29
	do	do	do	do
	do	do	White Tartar (C.I. 351)	do
	do	do	Biffen's White Wonder (C.I. 2011)	do
	Blacksburg, Va.	do	Cultivated oats	6-21-29
	do	do	do	do
	Colby, Kan.	C.O. Johnston	do	6-21-29
	Roanoke, Va.	Hutton and Stakman	do	6-22-29
	do	do	do	do
	Harlan, Ia.	P.W. Rohrbaugh	do	do
	Booneville, Ia.	do	do	6-25-29
	Linn, Mo.	do	do	do
	do	do	do	do
	Nettleton, Mo.	do	do	do
	Ottumwa, Ia.	do	do	6-27-29
	do	do	do	do
	Manhattan, Kan.	H.C. Murphy	_Avena strigosa_ (C.I. 1782)	do
	do	do	do	do
	do	do	Sunrise (C.I. 982)	do
	do	do	Sunrise Sel. 73	do
	Sioux Falls, S.D.	do	Kherson	7-3-29
	La Verne, Minn.	do	do	do
	Mankato, Minn.	do	Silvermine	7-5-29

Table 5. Continued.

Physiologic form	Place collected	Collector	Host	Date collected
	Iowa Falls, Ia.	H.C. Murphy	Kherson	7-6-29
	Ames, Ia.	do	Sunrise Sel. 73	7-17-29
	do	do	Cultivated oats	8-4-29
	do	do	do	do
	Corvallis, Ore.	E.N. Bressman	Iogold (C.I. 2329)	8-24-29
	do	do	do	do
	do	do	Cultivated oats	do
	Morgantown, W.Va.	H.C. Murphy	Black Mesdag (C.I. 1877)	9-17-29
	do	do	Gopher x Black Mesdag	do
	do	do	Hybrid oats	do
	Gainesville, Fla.	A.H. Eddins	Cultivated oats	3-3-30
	Leesburg, Fla.	W.B. Tisdale	Red Rustproof	3-14-30
	Gainesville, Fla.	A.H. Eddins	Cultivated oats	3-25-30
	do	do	do	do
Puccinia coronata avenae form 2	Libson, N.D.	S.M. Dietz	Volunteer oats	8-26-27
Puccinia coronata avenae form 3	Ste Anne de la Pocatiere, Que.,Can.	H.B. Humphrey	Victory (near Rhamnus cathartica	8-23-27
	Jackson Co., Ia.	J.M. Steddens	Rhamnus cathartica	5-23-28
	Millard, Nebr.	P.W. Rohrbaugh	do	5-27-28
	Waverly, Ohio	J.W. Baringer	Cultivated oats	7-13-28
	Montrose, W.Va.	S.H. Murphy	Iogold (C.I. 2329)	7-16-28
	Kingston, Ont.	W.P. Raleigh	Cultivated oats	7-29-28
	Ames, Ia.	H.C. Murphy	Iowa 102 (C.I. 2464)	9-23-28
	do	do	do	do
	do	do	Rhamnus infectoria (aecial cup No. 10)	4-26-29

Table 5. Continued.

Physiologic form	Place collected	Collector	Host	Date collected
	Harlan, Ia.	P.W. Rohrbaugh	Cultivated oats	6-22-29
	Farmington, Ia.	do	do	6-25-29
	Nettleton, Mo.	do	do	do
	Ames, Ia.	H.C. Murphy	Oats near *Rhamnus cathartica*	7-12-29
	do	do	do	do
	do	do	Markton (C.I. 2053)	7-17-29
	do	do	do	do
	Ryder, N.D.	A.A. Ziegler	*Rhamnus cathartica*	8-2-29
	do	do	do	do
	do	do	do	do
	do	do	do	do
	Morgantown, W.Va.	H.C. Murphy	Hybrid 17-10-48	9-17-29
	do	do	do	do
	do	do	Gopher x Black Mesdag	do
	Ames, Ia.	do	Iowa 102 (C.I. 2454)	10-2-29
	do	do	do	do
	do	do	Iowa 444 (C.I. 2331)	do
	do	do	*Rhamnus cathartica*	3-27-30
	do	do	do	do
	do	do	do	3-29-30
	do	do	do	do
	do	do	do	3-30-30
	do	do	*Rhamnus infectoria*	3-30-30
	do	do	do	do
Puccinia coronata avenae form 4	Urbana, Ill.	L.D. Leach	Volunteer oats	9-14-27

Table 5. Continued.

Physiologic form	Place collected	Collector	Host	Date collected
Puccinia coronata avenae form 5	Fulton, Mo.	L.D. Leach	Volunteer oats	9-18-27
	Mason City, Ia.	H.C. Murphy	d do	10-13-27
	Del Rio, Tex.	J.M. Raeder	Cultivated oats	5-9-28
	Nashville, Tenn.	S.M. Dietz	do	5-17-28
	Gainesville, Fla.	A.H. Eddins	do	5-18-28
	Afton, Ia.	F.H. Mendell	*Rhamnus lanceolata*	5-21-28
	Experiment, Ga.	S.M. Dietz	Winter Turf	5-23-28
	Tifton, Ga.	do	Cultivated oats	5-24-28
	A. & M. College, Miss.	do	do	5-26-28
	Denton, Tex.	do	Anthony (C.I. 2143)	5-27-28
	do	do	Cultivated oats	5-28-28
	Gainesville, Tex.	do	do	5-29-28
	Stillwater, Okla.	do	do	5-30-28
	Watonsville, Calif.	L.D. Leach	Cultivated oats	5-31-28
	Experiment, Ga.	J.S. Hadden	Guyra	6-9-28
	do	do	Laurel Skinless	do
	A. & M. College, Miss.	D.C. Neal	Iowa 102 (C.I. 2464)	do
	do	do	Iowa 69 (C.I. 2463)	do
	do	do	Iowa 77	do
	Ames, Ia.	H.C. Murphy	*Rhamnus lanceolata*	6-15-28
	do	do	do	do
	do	do	do	6-17-28
	do	do	do	do
	do	do	do	6-18-28
	Astoria, Ore.	H.B. Humphrey	Cultivated oats	6-25-28
	Canton, Mo.	P.W. Rohrbaugh	do	6-29-28
	Sac City, Ia.	Dietz and Murphy	do	7-7-28
	Hinton, Ia.	do	do	7-8-28
	Devil's Lake, N.D.	H.B. Humphrey	*Avena fatua*	7-27-28
	Ames, Ia.	H.C. Murphy	Iowa 102 (C.I. 2464)	9-23-28
	do	do	do	do

Table 5. Continued.

Physiologic form	Place collected	Collector	Host	Date collected
	Ames, Ia.	H.C. Murphy	*Rhamnus infectoria* (aecial cup No. 4)	4-26-29
	do	do	do, (aecial cup No. 8)	do
	Knoxville, Tenn.	do	Iomine	5-13-29
	do	do	do	do
	do	do	Anthony (C.I. 2143)	do
	do	do	do	do
	Experiment, Ga.	do	do	5-15-29
	do	do	do	do
	Tifton, Ga.	do	do	5-16-29
	do	do	do	do
	Auburn, Ala.	do	Cultivated oats	5-20-29
	do	do	do	do
	A. & M. College, Miss.	do	Iomine	5-22-29
	do	do	do	do
	do	do	Anthony (C.I. 2143)	do
	do	do	*Avena brevis* (C.I. 1783)	do
	do	do	Sunrise (C.I. 982)	do
	Denton, Tex.	do	Anthony (C.I. 2143)	6-1-29
	do	do	do	do
	do	do	Sunrise (C.I. 982)	do
	Lawton, Okla.	do	Colburt (C.I. 2019)	6-4-29
	Stillwater, Okla.	do	Iomine	6-6-29
	do	do	do	do
	do	do	Anthony (C.I. 2143)	do
	do	do	do	do
	Manhattan, Kan.	do	do	6-11-29
	do	do	Sunrise Sel. 73	do
	Knoxville, Tenn.	T.R. Stanton	White Tartar (C.I. 551)	6-19-29

Table 5. Continued.

Physiologic form	Place collected	Collector	Host	Date collected
	Knoxville, Tenn.	T.R. Stanton	Biffen's White Wonder (C.I. 2011)	6-19-29
	do	do	Iowa 77	do
	do	do	do	do
	Colby, Kan.	C.O. Johnston	Cultivated oats	6-21-29
	Hamburg, Va.	Hutton and Stakman	do	6-22-29
	do	do	do	do
	Booneville, Ia.	P.W. Rohrbaugh	do	6-25-29
	Manhattan, Kan.	H.C. Murphy	Sunrise (C.I. 982)	6-27-29
	do	do	Sunrise Sel. 73	do
	La Verne, Minn.	do	Kherson	7-3-29
	Mankato, Minn.	do	Silvermine	7-5-29
	Ames, Ia.	do	Iomine	7-17-29
	do	do	Victoria (C.I. 2401)	do
	do	do	Sunrise Sel. 73	do
	Corvallis, Ore.	E.N. Bressman	Cultivated oats	8-24-29
	Morgantown, W. Va.	H.C. Murphy	Black Mesdag	9-17-29
	Ames, Ia.	do	Iowa 102 (C.I. 2464)	10-2-29
	do	do	do	do
	do	do	Volunteer oats	do
	do	do	do	do
	do	do	do	do
	Gainesville, Fla.	A.H. Eddins	Cultivated oats	3-3-30
	do	do	do	do
	Leesburg, Fla.	W.B. Tisdale	Red Rustproof	3-14-30
	do	do	do	do
	Gainesville, Fla.	A.H. Eddins	Cultivated oats	3-25-30
	do	do	do	do
	Ames, Ia.	H.C. Murphy	*Rhamnus lanceolata*	3-30-30
	do	do	do	do

Table 5. Continued.

Physiologic form	Place collected	Collector	Host	Date collected
	Gainesville, Fla.	A.H. Eddins	Cultivated oats	4-3-30
	do	do	do	do
	Ames, Ia.	H.C. Murphy	*Rhamnus infectoria*	4-5-30
Puccinia coronata avenae form 6	Denton, Tex.	P.B. Dunkle	Volunteer oats	11-6-27
	Iowa Falls, Ia.	H.C. Murphy	Kherson	7-6-29
	Ames, Ia.	do	Sunrise (C.I. 982)	7-17-29
	do	do	do	do
Puccinia coronata avenae form 7	Ames, Ia.	H.C. Murphy	*Rhamnus tinctoria*	6-15-28
Puccinia coronata avenae form 8	Ames, Ia.	H.C. Murphy	*Rhamnus spp.* (from Mont.)	6-15-28
Puccinia coronata avenae form 9	Ames, Ia.	H.C. Murphy	*Rhamnus infectoria*	6-15-28
Puccinia coronata avenae form 10	Farmington, Ia.	P.W. Rohrbaugh	Cultivated oats	6-22-29
	Montrose, W.Va.	H.C. Murphy	Volunteer oats	9-1-29
	do	do	do	do
	Morgantown, W.Va.	do	Gopher (C.I. 2027)	9-17-29
	do	do	do	do
	do	do	Hybrid oats	do
	do	do	Hybrid 17-10-1	do
	Ames, Ia.	do	Iowa 444 (C.I. 2331)	10-2-29
	Conesville, Ia.	D.V. Layton	Volunteer oats	10-6-29
	do	do	do	do
	Ames, Ia.	H.C. Murphy	*Rhamnus tinctoria*	3-27-30
	do	do	*Rhamnus spp.* (from Mont.)	

Table 5. Continued.

Physiologic form	Place collected	Collector	Host	Date collected
Puccinia coronata avenae form I1	Parsons, Kan.	C.O. Johnston	Cultivated oats	6-16-29
	Bowling Green, Mo.	P.W. Rohrbaugh	do	6-26-29
	do	do	do	do
	Indianola, Ia.	do	do	6-29-29
	do	do	do	do
	Montrose, W. Va.	H.C. Murphy	Volunteer oats	9-1-29
	do	do	do	do
	Morgantown, W. Va.	do	Hybrid 17-10-1	9-17-29
Puccinia coronata avenae form I2	Ames, Ia.	H.C. Murphy	*Rhamnus* spp. (from Mont.)	4-26-29
	do	do	*Rhamnus infectoria* (aecial cup No. 1)	do
	do	do	do (aecial cup No.3)	do
	do	do	do (aecial cup No.5)	do
	do	do	do (aecial cup No.6)	do
	do	do	do (aecial cup No.7)	do
	do	do	do (aecial cup No.9)	do
	do	do	do (aecial cup No.11)	do
	do	do	do (aecial cup No.12)	do
	do	do	do (aecial cup No.13)	do
	do	do	*Rhamnus* spp. (from Mont.)	4-27-29
	do	do	do	do
	do	do	do	3-27-30
	do	do	*Rhamnus infectoria*	do
	do	do	*Rhamnus tinctoria*	do
	do	do	do	3-30-30
	do	do	*Rhamnus* spp. (from Mont.)	do
	do	do	*Rhamnus tinctoria*	do

Table 5. Concluded.

Physiologic form	Place collected	Collector	Host	Date collected
Puccinia coronata	Ames, Ia.	H.C. Murphy	*Rhamnus infectoria* (aecial cup No. 2)	4-26-29
avenae	do	do	*Rhamnus infectoria*	4-5-30
form 13	do	do	*Rhamnus chlerophera*	4-5-30
	do	do	do	do

Seventy cultures collected during the years 1927, 1928, 1929, and 1930 were identified as physiologic form 1. This form is apparently widely distributed throughout the United States and common in occurrence. (Fig. 1). Form 1 was not identified in cultures collected from Rhamnus and its distribution may be independent of an alternate host. It apparently hibernates in the south and probably moves north during the spring and summer.

Physiologic form 2 was identified in only one culture, collected in North Dakota in 1927 by Dr. S. M. Dietz. It may have originated on Rhamnus and it is apparently a comparatively rare form.

Thirty-three cultures were identified as physiologic form 3. Although a comparatively weak form and limited to the central and northeastern oat-growing regions of the United States, form 3 is important because few of the northern oat varieties are resistant to it. The principal source of collection of form 3 was on *Rhamnus cathartica*, both naturally and artificially infected. It was also collected on oats in Iowa, Ohio, West Virginia, Ontario, and Quebec. However, all of the cultures collected from oats were either, from plants growing near infected *R. cathartica*, or from a region where this species is common. Therefore, it seems probable that form 3 is disseminated from *R. cathartica*.

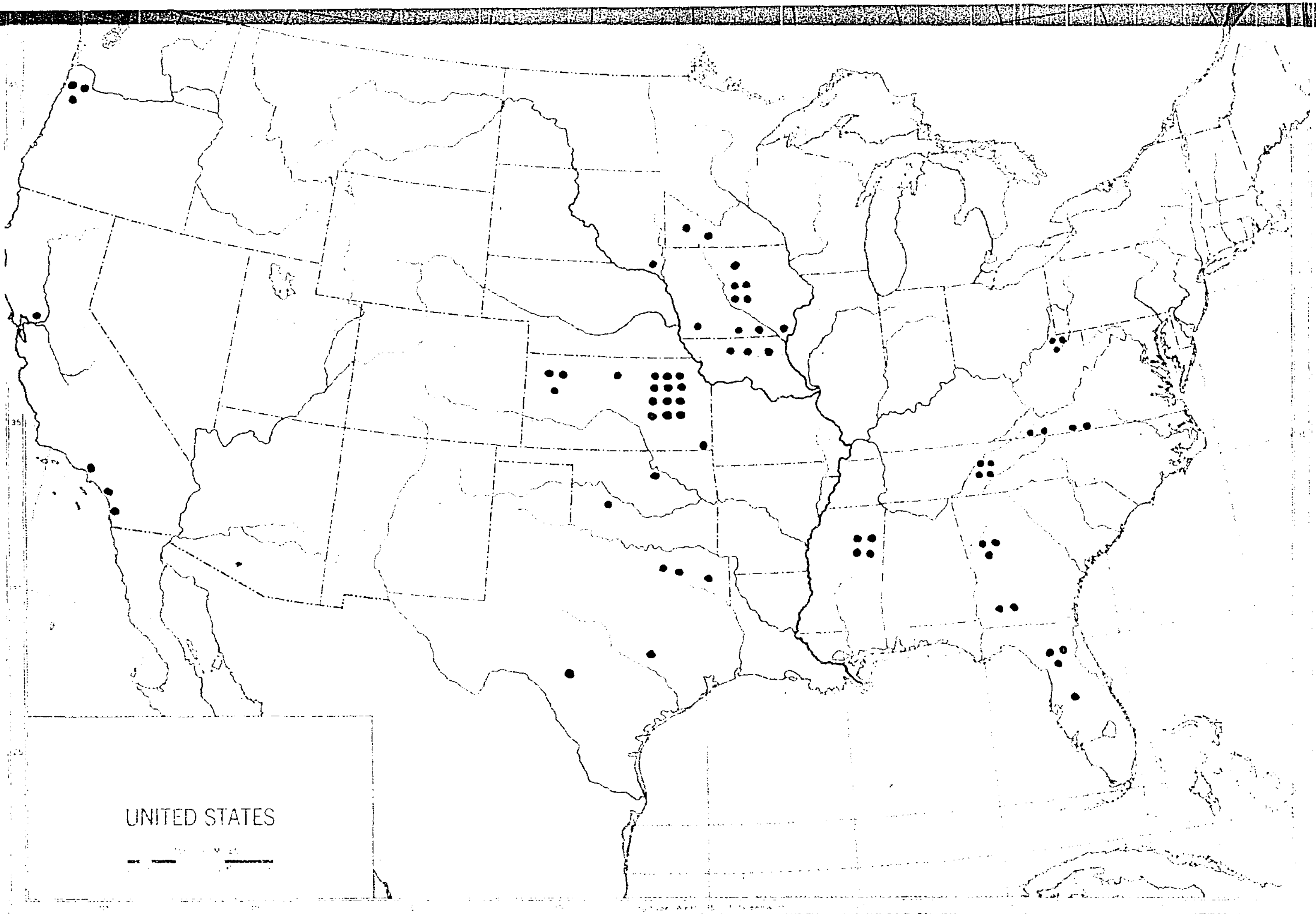

Figure 1. Geographic distribution of Puccinia coronata avenae, physiologic form 1, during 1927-30.

Rhamnus cathartica bushes are widely distributed in this northern oat growing region and will probably continue to furnish a source of inoculum of form 3. Dietz (20) has shown that *R. cathartica* is effective in disseminating crown rust. *Rhamnus infectoria*, another host for this form, is not native in America.

Physiologic form 4 was collected only once, at Urbana, Illinois, by Mr. L.D. Leach. It is somewhat similar to form 2 in virulence.

The most prevalent, widespread, and virulent form studied is number 5. Ninety-one of the 245 cultures collected during 1927, 1928, 1929, and 1930, were identified as belonging to this form. It is common in occurrence throughout all regions of the United States from which collections were secured (Fig.2). This form was collected on oats and on both *R. lanceolata* and *R. infectoria*. The former, which is widely distributed in the central portion of the United States, probably disseminates this form. Form 5 hibernates in the south and probably moves northward during the spring and summer.

Physiologic form 6, collected only on oats, was identified in cultures: once from Denton, Texas, in 1927; once from Iowa Falls, Iowa, in 1930, and twice from Ames, Iowa, in 1930.

Physiologic forms 7, 8, and 9, collected respectively from *R. tinctoria*, *R. spp.* (from Montana), and *R. infectoria*, were each identified once.

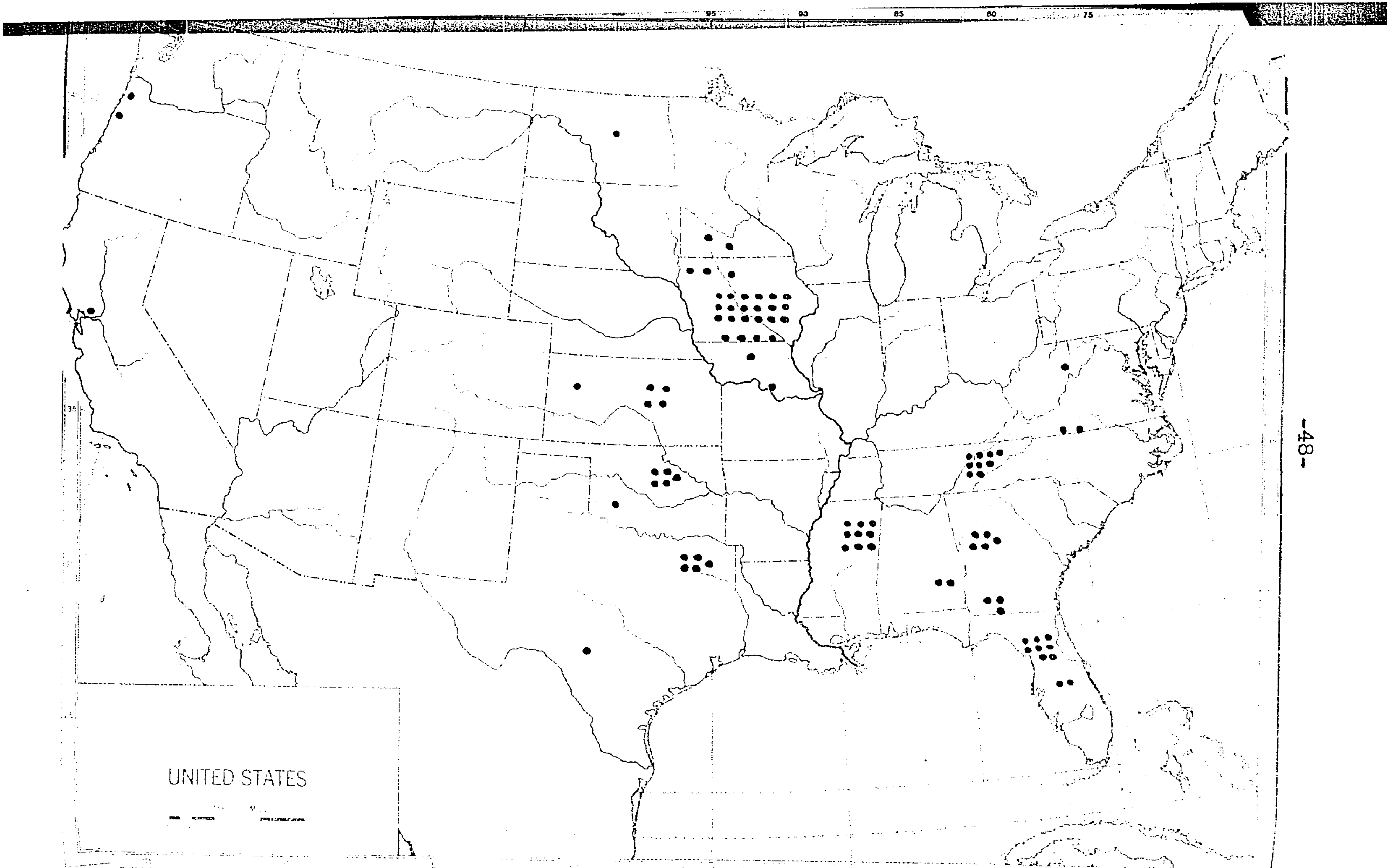

Figure 2. Geographic distribution of Puccinia coronata avenae, physiologic form 5, during 1927-30.

Physiologic form 10, identified in 12 cultures, ten from Avena in West Virginia and Iowa, and two from Rhamnus, one from R. infectoria and one from R. spp. (from Montana), is apparently a comparatively rare form.

Physiologic form 11, a comparatively rare form, was identified in eight cultures collected in Kansas, Missouri, Iowa, and West Virginia. This form was not collected on Rhamnus.

Physiologic forms 12 and 13 came only from Rhamnus. Form 12 was identified in 18 cultures isolated from collections secured from R. infectoria and R. tinctoria. Form 13 was identified in four cultures coming from R. infectoria, R. chlorophora, and R. spp. (from Montana).

The prevalence of each of the 13 forms during the years 1927, 1928, 1929, and 1930 and their distribution on Rhamnus and Avena hosts is given in table 6.

Table 6. Distribution of 13 physiologic forms of *Puccinia coronata avenae* on Avena and Rhamnus hosts during 1927, 1928, 1929, and 1930.

Physiologic form number	Number of cultures from Avena and Rhamnus during: 1927		1928		1929		1930		Total
	Avena	Rhamnus	Avena	Rhamnus	Avena	Rhamnus	Avena	Rhamnus	
1	4	-	6	-	56	-	4	-	70
2	1	-	-	-	-	-	-	-	1
3	1	-	3	4	13	5	-	7	33
4	1	-	-	-	-	-	-	-	1
5	2	-	23	6	47	2	8	3	91
6	1	-	-	-	3	-	-	-	4
7	-	-	-	1	-	-	-	-	1
8	-	-	-	1	-	-	-	-	1
9	-	-	-	1	-	-	-	-	1
10	-	-	-	-	10	-	-	2	12
11	-	-	-	-	8	-	-	-	8
12	-	-	-	-	-	12	-	6	18
13	-	-	-	-	-	1	-	3	4
Total per species	10	-	32	13	137	20	12	21	245
Total per year	10		45		157		33		245

Eight of the 13 forms were each identified in more than one culture. In order of their prevalence, these forms are 5, 1, 3, 12, 10, 11, 13, and 6. Forms 1, 2, 4, 6, and 11 were collected only from Avena species. While forms 7, 8, 9, 12, and 13 were collected only from Rhamnus species. Forms 3, 5, and 10 were collected on both Rhamnus and Avena.

Physiologic Forms Collected on Rhamnus

The distribution of the forms obtained from Rhamnus according to the species from which they were collected is given in table 7.

Table 7. Physiologic forms identified and number of cultures collected from different species of Rhamnus during 1928, 1929, and 1930.

Rhamnus host	Number of cultures identified as form number:							
	3	5	7	8	9	10	12	13
R. cathartica	13	-	-	-	-	-	-	-
R. chlorophora	-	-	-	-	-	-	-	2
R. infectoria	3	3	-	-	1	-	10	2
R. lanceolata	-	8	-	-	-	-	-	-
R. spp. (from Montana)	-	-	-	-	-	-	-	2
R. tinctoria	-	-	1	-	-	1	3	-

In these data certain species of Rhamnus produced only one physiologic form of crown rust, while other species produced as many as five. Both naturally and artificially infected plants of <u>Rhamnus</u> <u>lanceolata</u> have consistently produced only physiologic form 5. While naturally and artificially infected plants of <u>R. cathartica</u> have consistently produced only form 3. A total of five physiologic forms have been isolated from <u>R. infectoria</u>. In the light of the investigations conducted by Dietz (21), Craigie (14, 15, 16, 17, 18), Hanna (33), Newton, Johnson and Brown (51), Stakman, Levine and Cotter (64), and Allen (1), it seems probable that certain of these forms, particularly those of rare occurrence, may have arisen as a result of hybridization.

On September 23, 1928, a collection of volunteer Iowa 102 (C.I. 2464) oat plants was secured at Ames, Iowa. These plants heavily infected with crown rust, both in the telial and uredinial stages. Nine different single-uredinium cultures were identified, from the urediniospore material collected, using the possible differential hosts given in table 4. Six of these cultures were found to be physiologic form 5 and three physiologic form 3. Early in March, 1929, the telial material of this same collection was used to inoculate plants of <u>R. infectoria</u> and <u>R. spp.</u> (from Montana). Abundant infection was secured on both species. A total of 16 unopened aecial cups, 13 from <u>R. infectoria</u> and 3 from <u>R. spp.</u> (from Montana), were carefully picked with sterilized forceps. The aeciospores from each of these aecial cups were used to inoculate Markton plants and the single-uredinium isolations were identified in the usual manner. The thirteen cultures obtained from the same number of aecial cups from _R. infectoria_ were identified as follows: nine were form 12; two were form 5; one was form 3, and one was form 13. The three cultures from _R. spp._ (from Montana) were identified as form 12.

The above evidence, although circumstantial, strongly indicates that new physiologic forms are being produced on certain species of Rhamnus. This may partly account for the number of new forms collected only on Rhamnus. The fact that the teliospores were collected from a pure-line selection of Iowa 102 (C.I. 2464), which is highly resistant to form 12, is still further evidence that this form was probably not present in the original collection and that it may have originated on _R. infectoria_ and _R. spp._ (from Montana).

Physiologic Forms Collected on Oats

Crown rust of oats probably does not hibernate farther north than the northern limit of over-wintering of volunteer oats. Those physiologic forms that hibernate in this southern region should be available for collection before those forms that originate on Rhamnus have appeared. Physiologic form 1 was collected as early as February 6 at Denton, Texas, during 1928, and both forms 1 and 5 were collected March 30, 1930, at Gainesville, Florida. The occurrence of the thirteen physiologic

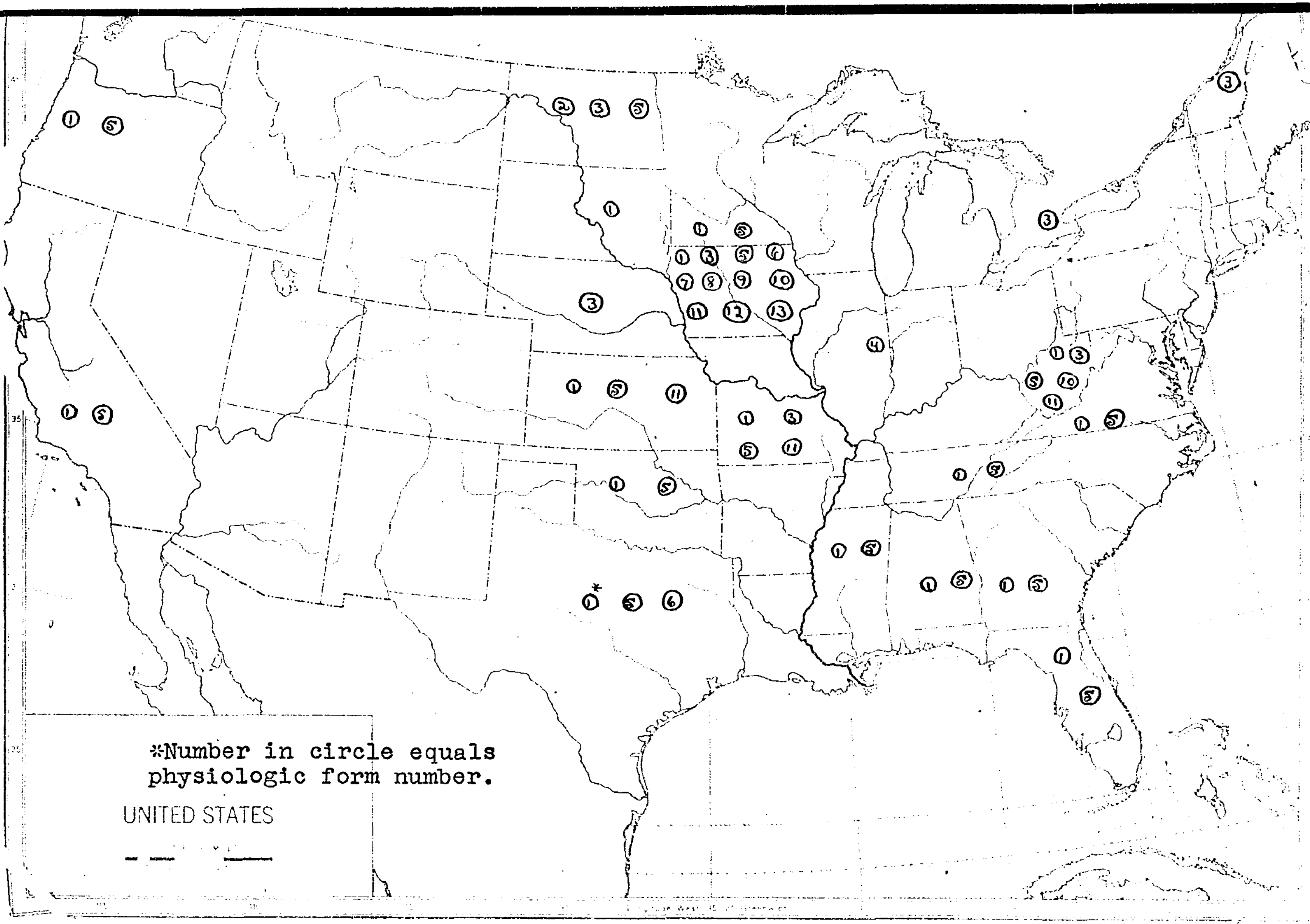

Figure 3. Physiologic forms of Puccinia coronata avenae collected from different states and Canada during the period 1927-30.

RESPONSE OF VARIETIES, SELECTIONS, AND SPECIES

It is very desirable to know the reaction of the most important agronomic varieties of oats to the most widely distributed physiologic forms. The forms identified most frequently were numbers: 1, 3, 5, 10, 11, and 12.

A uniform oat crown rust nursery was grown at Ames, Iowa, and Experiment, Georgia, during 1926, 1927, and 1928, and again in 1929, with a few changes, at Ames, Iowa, Experiment, Georgia, Knoxville, Tennessee, Tifton, Georgia, A. & M. College, Mississippi, Baton Rouge, Louisiana, Denton, Texas, Stillwater, Oklahoma, and Manhattan, Kansas. The per cent of crown rust infection on each of the varieties, selections, and species included in these various nurseries was determined. In addition the seedling reaction of these same varieties, selections, and species, to physiologic forms 1, 3, 5, 10, 11, and 12 was determined under greenhouse conditions.

In table 8 is given the average type of infection on each of these varieties, selections, and species with physiologic forms 1, 3, 5, 10, 11, and 12, and the percentage of crown rust infection observed on these same varieties, selections, and species, under field conditions at various locations in the United States. The nurseries omitted either escaped infection or the observations were untimely for satisfactory comparisons.

Table 8. Reaction of certain varieties, selections and species of oats to six physiologic forms of *Puccinia coronata avenae*, and the per cent of crown rust infection on these varieties under field conditions.

Variety, selection, or species	C.I. number	Average type of seedling reaction to physiologic form number: 1	3	5	10	11	12	Per cent of crown [rust] various locations: Experiment: Georgia 1927*	Georgia 1928	Ames, Iowa 1926*	Ames, Iowa 1927*	Ames, Iowa 1929	Manhattan: Kansas 1929	A. & M. Missis[sippi] 19[..]
Alabama Hybrid	971	4	4	4	4	4	4	75	10	70	30	55	30	5
Albion	729	4	4	4	4	4	4					25	50	
Alcot White (64)**		4	4	4	0	4	0	40	t	70	40	25	50	7
Algerian	3579	4	1	4	4	4	4	20	1	20	20	10	15	1
do	840	4	0	4	0	4	0					20	30	
do	2052	4	0	4	1	1	1					5	30	
do	989	4	4	4	4	4	4					25	25	
Algerian (69)		4	0	4	4	4	4	35	t	25	55	15	25	1
Algerian (140)		4	4	4	1	4	1					15	55	
Algerian Cape	1002	4	0	4	0	1	2					5	35	
Algerian x Calcutta	2807	4	4	4	4	4	4	5	5		20	20	40	[illegible]
Anthony	2143	0	4	4	0	0	0					15	45	2
Argentine	993	4	4	4	2	2	2					5	50	
Aurora	831	4	4	4	4	4	4					50	65	
Awnless Culred	1776	4	4	4	4	4	4					25	60	
Awnless Monarch	1879	4	4	4	4	4	4					15	35	
Awnless Probstier	1888	4	4	4	4	4	4					15	40	
Awnless Rustproof	1776	4	4	4	4	4	4					35		
Avena abbysinica (225)		0	4	4	4	4	4					15	50	
A. brevis	1783	0	0	4	4	4	4					5	5	
A. brevis (70)	2762	3	0	4	4	3	4					10	10	(
A. brevis (228)		4	3	4	3	4	2					t	10	
A. strigosa (226)		4	4	4	4	4	4					t	25	
do	1782	4	0	3	4	4	4					5	15	
A. strig. glaberscens	2830	0	0	0	4	0	0					0	0	
A. sterilis (220)		4	4	4	4	4	4					40	45	

lections and species of oats to six
onata avenae, and the per cent of crown
under field conditions.

e of action gic form r: 11	12	Per cent of crown rust infection observed at various locations during the years indicated: Experiment: Georgia 1927*	1928	Ames, Iowa 1926*	1927*	1929	Manhattan: Kansas 1929	A. & M. College: Mississippi 1929	Tifton Georgia 1929	Denton Texas 1929	Stillwater Oklahoma 1929
4	4	75	10	70	30	55	30	50	5	20	20
4	4					25	50				
4	0	40	t	70	40	25	50	70	30	35	15
4	4	20	1	20	20	10	15	10	t	10	20
4	0					20	30				
1	1					5	30				
4	4					25	25				
4	4	35	t	25	55	15	25	10	t	15	15
4	1					15	35				
1	2					5	35				
4	4	5	5		20	20	40	t	5	t	t
0	0					15	45	25	40	20	10
2	2					5	60				
4	4					50	65				
4	4					25	60				
4	4					15	35				
4	4					15	40				
4	4					35					
4	4					15	50				
4	4					5	5				
3	4					10	10	0	0	0	0
4	2					t	10				
4	4					t	25				
4	4					5	15				
0	0					0	0				
4	4					40	45				

Table 8. Continued.

Variety, selection, or species	C.I. number	Average type of seedling reaction to physiologic form number: 1	3	5	10	11	12	Experiment: Georgia 1927*	Georgia 1928	Ames, Iowa 1926*	Ames, Iowa 1927*	Ames, Iowa 1929	Per cent of crown … various locations: Manhattan, Kansas 1929	A. & M., Missi… 1…
"Avena capa"	2765	3	0	3	I	0	0							
"Avena victoria"	2764	0	0	0	I	0	0							
"Avena 64a"	2767	3	0	3	0	0	0							
"Avena 1095a"	2766	4	0	4	0	1	0							
Avoine de Maroc	1789	4	4	4	0	0	0						10	
Bathurst	1810	4	0	4	0	4	0	15	t	55	5	5	10	
Belar Sel. (1)		4	0	4	0	4	0					t	10	
Belar (65)	2760	4	0	4	0	4	0	20	1	15	10	5	15	
Belar (82)	2770	4	1	4	1	4	1	15	1	20	20	5	15	
Belyak	1630	4	4	4	4	4	4					35	50	
Bicknell	206-151	4	2	4	0	4	0					40	50	
Biffen's White Winter	2011	4	4	4	4	4	4	60	10	85	55	30	50	
do	2012	4	4	4	4	4	4	60	5	85	60	45	50	
Black Algerian	204	4	1	4	0	4	0	40	5	15	20	5	5	
do	640-1	4	4	4	0	4	0					15		
do	2051	4	1	4	4	4	4	40	2	20	60	5	30	
Black Bell I	1767	4	4	4	4	4	4					15	50	
Black Bell II	1308	4	4	4	4	4	4					25	50	
Black Diamond	1782	4	4	4	4	4	4					15	60	
do	1878	4	4	4	4	4	4					45		
Black Mesdag	1877	4	4	4	4	4	4					45	70	
Black Mogul	1074	4	4	4	4	4	4					55		
Black President	1992	3	4	4	4	4	4					60	50	
Black Rival	807	4	4	4	4	4	4					40	60	
Black Speckled	1317	4	4	4	4	4	4					65	55	
Black Tartar	991	4	2	4	4	4	4					25	30	
Black Winter	306	4	4	4	4	4	4					25	50	
Blagodatnoe	2058	4	4	4	4	4	4					25	40	

...pe of ...action ...ie form			Experiment: Georgia		Ames, Iowa			Manhattan Kansas	A. & M. College Mississippi	Tifton Georgia	Denton Texas	Stillwater Oklahoma
10	11	12	1927*	1928	1926*	1927*	1929	1929	1929	1929	1929	1929
I	0	0										
I	0	0										
0	0	0										
0	1	0										
0	0	0						10				
0	4	0	15	t	55	5	5	10	60	10	t	t
0	4	0					t	10				
0	4	0	20	1	15	10	5	15	20	20	5	t
1	4	1	15	1	20	20	5	15	10	t	5	t
4	4	4					35	50				
0	4	0					40	50				
4	4	4	60	10	85	55	30	50	85	30	25	5
4	4	4	60	5	85	60	45	60	75	30	30	5
0	4	0	40	5	15	20	5	5	40	10	5	t
0	4	0					15					
4	4	4	40	2	20	60	5	30	45	10	10	t
4	4	4					15	50				
4	4	4					25	50				
4	4	4					15	50				
4	4	4					45					
4	4	4					45	70				
4	4	4					55					
4	4	4					60	50				
4	4	4					40	60				
4	4	4					65	55				
4	4	4					25	30				
4	4	4					25	50				
4	4	4					25	40				

Per cent of crown rust infection observed at various locations during the years indicated

Table 8. Continued.

Variety, selection, or species	C.I. number	Average type of seedling reaction to physiologic form number: 1	3	5	10	11	12	Per cent of crown rust at various locations: Experiment, Georgia 1927*	Georgia 1928	Ames, Iowa 1926*	Ames, Iowa 1927*	Ames, Iowa 1929	Manhattan, Kansas 1929	A. & M. Missis[illegible] 19[illegible]
Blue Stem (97)		4	0	4	0	4	0	10	5		50	20	40	[illegible]
Boree (53)		4	4	3	4	4	4	60	1	55	40	40	50	[illegible]
Boswell	480	4	4	4	4	4	4					40	70	
"Bright Yellow"	1816	4	4	4	4	4	4					70	50	
Buddah (62)		4	4	4	4	4	4	40	t			20	35	[illegible]
Budgery (48)		4	4	4	4	4	4	30	5	20	20	15	50	[illegible]
Burran (56)		4	4	4	4	4	4	75	1	70	10	40	30	[illegible]
Burt	1436	4	4	4	4	4	4					40		
do	1861	4	4	4	4	4	4					20	50	
do	2043	4	4	4	0	4	0					25	45	
do	2054	4	4	4	4	4	4	75	1	65	30	20	50	[illegible]
Burt (90)		4	4	4	4	4	4	70	5	60	40	20	40	[illegible]
Calcutta	994	4	4	4	4	4	4					40	25	
Calcutta x Cape	2802	0	0	4	0	2	0	20	t	20	55	5	40	[illegible]
Canadian	1625	4	4	4	4	4	4					40	60	
Castleton Potato	1972	4	4	4	4	4	4					15	50	
Cassel	1859-4	4	0	4	0	3	1					25	50	
Chernishevka	2059-1	4	4	4	4	4	4					25	45	
do	2059-2	4	4	4	4	4	4					20	40	
Chinese	1003	4	4	4	4	4	4					40		
Chinese Hull-less (760)		4	4	4	4	4	4					50	70	
Choral	2060	4	4	4	4	4	4					5	50	
Coastblack	1025	4	4	4	4	4	4					5		
Cole	834	4	4	4	4	4	4					25	65	
Colburt	2019	4	4	4	4	4	4	75	20	65	55	10	50	
College Algerian	2052	4	0	4	0	4	0	30	5		10	25	30	
Colorado No. 37	1640	4	4	4	4	4	4							
Comewell	1317	4	4	4	4	4	4							
Cornellian	1242	4	4	4	4	4	4					10	40	

e of ction c form		Per cent of crown rust infection observed at various locations during the years indicated									
		Experiment, Georgia		Ames, Iowa			Manhattan, Kansas	A. & M. College, Mississippi	Tifton, Georgia	Denton, Texas	Stillwater, Oklahoma
11	12	1927*	1928	1926*	1927*	1929	1929	1929	1929	1929	1929
4	0	10	5		50	20	40	55	60	20	5
4	4	60	1	55	40	40	50	30	30	40	20
4	4					40	70				
4	4					70	50				
4	4	40	t			20	35	10	10	30	10
4	4	30	5	20	20	15	50	20	10	20	20
4	4	75	1	70	10	40	30	30	30	20	15
4	4					40					
4	4					20	50				
4	0					25	45				
4	4	75	1	65	30	20	50	65	40	15	10
4	4	70	5	60	40	20	40	10	10	10	5
4	4					40	35				
2	0	20	t	80	55	5	40	15	10	10	5
4	4					40	60				
4	4					15	50				
3	1					25	50				
4	4					25	45				
4	4					20	40				
4	4					40					
4	4					50	70				
4	4					5	60				
4	4					5					
4	4					25	65				
4	4	75	20	65	55	10	50	90	90	40	35
4	0	30	5		10	25	30	10	10	5	5
4	4										
4	4										
4	4					10	40				

Table 8. Continued.

Variety, selection, or species	C.I. number	Average type of seedling reaction to physiologic form number: 1	3	5	10	11	12	Per cent of crown … various locations: Experiment, Georgia 1927	Experiment, Georgia 1928	Ames, Iowa 1926	Ames, Iowa 1927	Ames, Iowa 1929	Manhattan, Kansas 1929	A. & M., Miss…
Cowra Sel. (4)		4	0	4	0	4	0					10	25	
Cowra (35)		4	0	4	0	4	0					25	45	
Cowra (50)	2761	4	0	4	0	4	0					40	50	
Culberson	273	4	4	4	4	4	4		15	70	75	60	60	
do	1873	4	4	4	4	4	4					40	60	
Culfed	516-189	4	4	4	4	4	4					55	60	
Custis	2041	4	0	4	0	0	0	50	35	55	85	60	55	
Danish Giant	1989	3	4	4	4	4	4					35	40	
Danish Island	1684	4	4	4	4	4	4					15	45	
do	1307	4	4	4	4	4	4					15	60	
Daubeney	1621	4	4	4	4	4	4					25	50	
D.A.C. No. 10	2829	4	2	4	0	4	0	50	40		20	40	45	
D.A.C. No. 12 (88)		4	4	4	4	4	4	50	10	25	35	30	45	
D.A.C. No. 17 (94)		4	4	4	4	4	4		40		80	50	50	
D.A.C. No. 19 (76)		4	4	4	4	4	4	75	20	55	35	50	60	
Diamond Hull-less	2640	4	4	4	4	4	4							
Dwarf Culberson	748	4	4	4	4	4	4					60	50	
Early Blondo (75)		4	2	4	1	4	0	60	t	70	25	35	50	
Early Burt (90)		4	0	4	0	4	0					20	45	
Early Burt (77)	2763	4	0	4	0	4	0	50	30	25		25	50	
Early Champion	1623	4	4	4	4	0	4					55	50	
Early Joanette	1092	4	4	4	4	4	4					20	60	
Early Joanette	1373	4	4	4	4	4	4					40		
do	1393	4	4	4	4	4	4							
Early May (98)	2828	4	0	4	0	4	0					10	45	
Early May (219)		4	1	4	4	4	4					25	35	
Early Mountain	1624	4	4	4	4	4	4					30	50	
Early Ohio	1117	4	4	4	4	4	4							
Early Ripe	2803	4	0	4	1	4	0	50	t	35	15	20	60	

rage type of ling reaction ysiologic form number: 5	10	11	12	Experiment Georgia 1927?	Experiment Georgia 1928	Ames, Iowa 1926?	Ames, Iowa 1927?	Ames, Iowa 1929	Manhattan Kansas 1929	A. & M. College Mississippi 1929	Tifton Georgia 1929	Denton Texas 1929	Stillwater Oklahoma 1929
4	0	4	0					10	25				
4	0	4	0					25	45				
4	0	4	0					40	50	25	t	20	5
4	4	4	4		15	70	75	60	60	95	20	35	30
4	4	4	4					40	60				
4	4	4	4					55	60				
4	0	0	0	30	35	55	85	60	55	95	20	10	10
4	4	4	4					35	40				
4	4	4	4					15	45				
4	4	4	4					15	60				
4	4	4	4					25	50				
4	0	4	0	50	40		20	40	45	70	60	30	25
4	4	4	4	50	10	25	35	30	45	30	t	15	10
4	4	4	4		40		80	50	50	60	t	20	20
4	4	4	4	75	20	55	35	50	60	85	10	30	35
4	4	4	4										
4	4	4	4					60	50				
4	1	4	0	60	t	70	25	35	50	30	60	25	20
4	0	4	0					20	45	10	10	15	5
4	0	4	0	50	30	25		25	50				
4	4	0	4					55	50				
4	4	4	4					20	60				
4	4	4	4					40					
4	4	4	4										
4	0	4	0					10	45	10	10	20	5
4	4	4	4					25	35				
4	4	4	4					30	50				
4	4	4	4										
4	1	4	0	50	t	35	15	20	50	15	40	20	5

Table 8. Continued.

Variety, selection, or species	C.I. number	Average type of seedling reaction to physiologic form number: 1	3	5	10	11	12	Experiment*: Georgia 1927a	1928	Ames, Iowa 1926a	1927a	1929	Per cent of crown rus[t] various locations dur[ing]: Manhattan, Kansas 1929	A. & M. Col[lege] Mississip[pi] 1929
Echo	1982	4	4	4	4	4	4					20	56	
Edkin Sel.	2330-459	4	4	4	1	4	0					35	45	
Empire	1974	4	4	4	4	4	4					40		
Extra Early (213)		4	0	4	4	0	4					25	60	
Ferguson Navarro	966	4	4	4	4	3	4							
Flores de Avila	1911	4	4	4	4	4	4					45	55	
Forward	2242	4	4	4	4	4	4					40		
Fowlds	1996	4	4	4	4	5	4							
Fortuna	1983	4	4	4	4	4	4					20	55	
Frazier	765	4	4	4	4	4	4					25	50	
do	765-19	4	0	4	4	4	4					30	60	
do	2331	4	4	4	4	4	4							
Fulghum	650-203	4	4	4	4	4	4	75	10	40	30	30	70	75
do	650-204	4	4	4	4	4	4	50	10	70	[illegible]	40	25	70
do	699-202	4	4	4	4	0	4	60	15	75	60	40	45	65
do	699-2011	4	4	4	4	4	4	76	25	70	60	70	50	50
do	699-2015	4	4	4	4	4	4	75	40	70	35	60	80	65
do	707	4	1	4	4	4	4					50	60	
do	708	4	4	4	4	4	4					70	80	
do	708-204	4	4	4	4	4	4	75	20	70	65	70	50	70
do	1360-217	4	4	4	4	4	4	50	10	25	55	30	60	55
Fulghum (83)		4	4	4	4	4	4	75	10	40	30	40	40	40
Fulghum x Hatchett (218)		4	4	4	4	4	4					40	60	
Fulmer	1959-1	4	4	4	4	4	4					15	35	
Garton No. 475	1613	4	4	4	4	4	4					25	70	
Garton No. 748	1862	4	4	4	4	4	4					25	50	
Garton No. 5	1984	4	4	4	4	4	4					15	40	
Garton Grey	1964	4	4	4	4	4	4					20	55	
Garton's Yellow (96)		4	4	4	4	4	4	35	15		20	30	50	80

...ago type of ...ing reaction ...siologic form number:				Experiment*					Per cent of crown rust infection observed at various locations during the years indicated				
				Georgia		Ames, Iowa			Manhattan: Kansas	A. & M. College: Mississippi	Tifton: Georgia	Denton: Texas	Stillwater: Oklahoma
9	10	11	12	1927*	1928	1926*	1927*	1929	1929	1929	1929	1929	1929
4	4	4	4					20	56				
4	1	4	0					35	45				
4	4	4	4					40					
4	4	0	4					25	60				
4	4	3	4										
4	4	4	4					45	55				
4	4	4	4					40					
4	4	3	4										
4	4	4	4					20	55				
4	4	4	4					25	50				
4	4	4	4					30	60				
4	4	4	4										
4	4	4	4	75	10	40	30	30	70	75	10	35	55
4	4	4	4	50	10	70	60	40	25	70	15	30	30
4	4	0	4	60	15	75	60	40	45	65	15	45	30
4	4	4	4	75	25	70	60	70	80	50		40	40
4	4	4	4	75	40	70	85	60	80	65		35	45
4	4	4	4					50	60				
4	4	4	4					70	80				
4	4	4	4	75	20	70	65	70	80	70	15	45	50
4	4	4	4	50	10	25	55	30	60	55	50	40	35
4	4	4	4	75	10	40	30	40	40	40	20	25	25
4	4	4	4					40	60				
4	4	4	4					15	35				
4	4	4	4					25	70				
4	4	4	4					25	50				
4	4	4	4					15	40				
4	4	4	4					20	55				
4	4	4	4	35	15		20	30	50	80	t	35	20

Table 8. Continued.

Variety, selection, or species	C.I. number	Average type of seedling reaction to physiologic form number: 1	3	5	10	11	12	Experiment: Georgia 1927*	Georgia 1928	Ames, Iowa 1926*	Ames, Iowa 1927*	Ames, Iowa 1929	Per cent of crow... various location... Manhattan, Kansas 1929	A. & M... Miss...
Garton's Yellow	1612	4	4	4	4	4	4					25	60	
Glenn Innis	980	4	4	4	4	4	4	20		45	20	10	10	
Gopher	2027	4	4	4	4	4	4					25	60	
Golden	2806	4	4	3	4	4	4	40	10	20	15	16	30	
Golden Drop	1780	4	4	4	4	4	4					20	50	
do	1988	3	4	4	4	4	4					25	35	
Golden Giant	1606	4	4	4	4	4	4					20	50	
Golden Sheaf	2056	4	4	4	4	4	4	75	t	50	10	20	25	
Gothland	1898	4	4	4	4	4	4					30	55	
Gray	2014	3	0	4	0	2	1	75	1	45	30	5	25	
Great Northern (74)		4	4	4	4	4	4	40	t	55	5	40	30	
Green Mountain	1892	0	4	4	1	1	0					15	35	
Green Russian	1040	4	4	4	4	4	4					10		
do	1978	4	4	4	4	4	4					25	60	
do	2342	4	4	4	4	4	4					40	45	
do	2344	4	4	4	4	4	4					5	10	
Guyra	981	4	0	4	0	0	0	t	t	75	55	40	50	
do	2034	3	3	4	4	3	3					35	50	
Guyra (51)	2768	4	4	4	4	4	4	20	t	20	40	15	10	
Hajira	1001	4	4	4	4	4	4					25	35	
Hamilton	2039	4	4	4	4	4	4	60	15	55	50	30	50	
Hatchett	838	4	4	4	4	4	4					50	50	
Hay	1622	4	4	4	4	4	4					15	15	
Hundred Bushel	2797	4	0	4	0	0	0					5	45	
Hutchson (217)		4	4	4	4	4	4					50	60	
Idamine	1834	4	4	4	4	4	4					40		
Iogold	2329	4	4	4	4	4	4					25	50	
Iogren	2024	4	4	4	4	4	4					30	35	
Iomine	2827	4	4	4	4	4	4					40	50	

rage type of lling reaction ysiologic form number:				Experiment: Georgia		Ames, Iowa			Per cent of crown rust infection observed at various locations during the years indicated				
									Manhattan: Kansas	A. & M. College: Mississippi	Tifton: Georgia	Denton: Texas	Stillwater: Oklahoma
6	10	11	12	1927*	1928	1926*	1927*	1929	1929	1929	1929	1929	1929
4	4	4	4					25	60				
4	4	4	4	20		45	20	10	10	50	20	t	0
4	4	4	4					25	60				
3	4	4	4	40	10	20	15	15	30	30	5	10	25
4	4	4	4					20	50				
4	4	4	4					25	35				
4	4	4	4					20	50				
4	4	4	4	75	t	50	10	20	25	95	30	20	15
4	4	4	4					30	55				
4	0	2	1	75	1	45	30	5	25	60	10	25	20
4	4	4	4	40	t	55	5	40	30	30	10	20	10
4	1	1	0					15	35				
4	4	4	4					10					
4	4	4	4					25	60				
4	4	4	4					40	45				
4	4	4	4					5	10				
4	0	0	0	t	t	75	65	40	50	50	20	25	20
4	4	3	3					35	50				
4	4	4	4	20	t	20	40	15	10	10	t	10	t
4	4	4	4					25	35				
4	4	4	4	60	15	55	50	30	50	30	40	30	t
4	4	4	4					50	50				
4	4	4	4					15	15				
4	0	0	0					5	45	5	t	5	10
4	4	4	4					50	60				
4	4	4	4					40					
4	4	4	4					25	50				
4	4	4	4					30	35				
4	4	4	4					40	50	20	20	20	10

Table 8. Continued.

Variety, selection, or species	C.I. number	Average type of seedling reaction to physiologic form number: 1	3	5	10	11	12	Per cent of crown … various locations: Experiment, Georgia 1927*	Georgia 1928	Ames, Iowa 1926*	Ames, Iowa 1927*	Ames, Iowa 1929	Manhattan, Kansas 1929	A. & M. … Missi… 1…
Iowa 69	2463	0	4	4	0	0	0					25	50	
Iowa 77	2813	0	4	4	0	0	0					20	40	
Iowa 102	2464	0	4	4	0	4	0					20	40	
Iowa 444	2331	4	4	4	4	4	4					20	35	
Iowar	847	4	4	4	4	4	4					25	50	
Irish Victor	1251	4	4	4	4	4	4					25	45	
Ithacan	2141	4	4	4	4	4	4					40		
Japan	1157	4	4	4	4	4	4					50		
do	1889	4	4	4	4	4	4					25	50	
Joanette	549	4	4	4	4	4	4					40		
do	1880	4	4	4	4	4	4					20	50	
June	1902	4	4	4	4	4	4					40		
Kanota	839	4	4	4	4	4	4					50	45	
Keystone	2140	4	4	4	4	4	4							
Kherson	459	4	4	4	4	4	4					45	60	
do	1885	4	4	4	4	4	4					40		
do	1905	4	4	4	4	4	4							
King	850	4	4	4	4	4	4	30	15	65	30	40	30	
Lachlan	983	4	4	4	4	4	4	60	15	55	35	40	40	
Lachlan (59)		4	4	4	4	4	4	75	1	75	40	45	60	
Lachlan (81)	2805	4	4	4	0	4	0	60	25	40	50	10	30	
Laurel Skinless (79)		4	4	4	4	4	4	50	60	65	15	40	50	
Lee	2042	4	1	4	0	4	0	50	50	40	85	45	65	
Liberty Hull-less	845	4	4	4	4	4	4					15	60	
Lincoln	1262	4	4	4	4	4	4					20	45	
Madrid	603	4	4	4	4	4	4					40	60	
Mansholt II	1990	4	4	4	3	4	4					30	40	
Mansholt III	2046	4	4	4	4	4	4					30	50	
Markton	2053	4	4	4	4	4	4					40	70	

e type of g reaction ologic form mber:			Per cent of crown rust infection observed at various locations during the years indicated										
			Experiment, Georgia		Ames, Iowa			Manhattan, Kansas	A. & M. College, Mississippi	Tifton, Georgia	Denton, Texas	Stillwater, Oklahoma
10	11	12	1927*	1928	1926*	1927*	1929	1929	1929	1929	1929	1929
0	0	0					25	50	10	30	20	5
0	0	0					20	40	10	30	20	6
0	4	0					20	40				
4	4	4					20	35				
4	4	4					25	50				
4	4	4					25	45				
4	4	4					40					
4	4	4					50					
4	4	4					25	50				
4	4	4					40					
4	4	4					20	50				
4	4	4					40					
4	4	4					50	45				
4	4	4										
4	4	4					45	60				
4	4	4					40					
4	4	4										
4	4	4	30	15	65	30	40	30	60	10	40	15
4	4	4	60	15	55	35	40	40	75	15	20	15
4	4	4	75	1	75	40	45	60	30	40	40	10
0	4	0	60	25	40	50	10	30	10	10	5	15
4	4	4	50	50	65	15	40	50	20	60	14	20
0	4	0	50	50	40	65	45	65	90	20	25	20
4	4	4					15	60				
4	4	4					20	45				
4	4	4					40	60				
3	4	4					30	40				
4	4	4					30	50				
4	4	4					40	70				

Table 8. Continued.

Variety, selection, or species	C.I. number	Average type of seedling reaction to physiologic form number: 1	3	5	10	11	12	Per cent of crown rust in various locations: Experiment: Georgia 1927a	Georgia 1928	Ames, Iowa 1926a	Ames, Iowa 1927a	Ames, Iowa 1929	Manhattan Kansas 1929	A. & M. Miss 1
Mortgage Lifter	2804	4	4	4	4	0	4	40	2	15	15	5	10	
Marvelous	1999	4	4	4	4	4	4					20	60	
Miami	2245	4	4	4	4	4	4					20		
Minota	1285	4	4	4	4	4	4					30	45	
Minn. No. 295	1295	4	4	4	4	4	4					50		
Monarch	1876	4	4	4	4	4	4					20	50	
Mongolian	1770	4	4	4	4	4	4					60		
Mogul	1070	4	4	4	4	4	4					30	65	
Nygall	2800	4	4	4	4	4	4	40	t			5	30	
Mulga (55)	2796	4	1	4	0	4	0	30	1			5	10	
Mulga (72)		4	0	4	4	4	4	30	10			5	25	
Navarro	966	4	4	4	4	4	4					65	60	
Nonsa	1984	4	4	4	4	4	4					10	30	
Nortex	2582	4	0	4	0	4	0					5	20	
North Finnish	1882	4	4	4	4	4	4					15	45	
O.A.C. No. 72	1896	4	4	4	4	4	4					15	60	
O.A.C. No. 144	846	4	4	4	4	4	4					35	40	
Odal	2047	4	4	4	4	4	4					40	60	
Old Island Black	2035	0	4	3	4	0	4					15	50	
do	1756	2	4	4	2	2	0							
Oriental	1593	4	4	4	4	4	4					40	60	
Orion	2048	4	4	4	4	4	4					25	60	
Patterson	2147	4	4	4	4	4	4							
Pringle Progress	1737	4	4	4	4	4	4							
Probstier	1656	4	4	4	4	4	4					10	60	
Red Algerian	840	4	0	4	0	4	0					15		
do	977	0	4	4	4	4	4					t	45	
do	1578	0	4	4	0	4	1					15	30	
do	1903-1	3	2	3	0	2	0					25	45	

ge type of ing reaction siologic form number:				Per cent of crown rust infection observed at various locations during the years indicated										
				Experiment, Georgia		Ames, Iowa			Manhattan, Kansas	A. & M. College, Mississippi	Tifton Georgia	Denton Texas	Stillwater Oklahoma
5	10	11	12	1927*	1928	1926*	1927*	1929	1929	1929	1929	1929	1929
4	4	0	4	40	2	15	15	5	10	t	15	t	5
4	4	4	4					20	60				
4	4	4	4					20					
4	4	4	4					30	45				
4	4	4	4					50					
4	4	4	4					20	50				
4	4	4	4					60					
4	4	4	4					30	65				
4	4	4	4	40	t			5	30	25	t	25	10
4	0	4	0	30	1			5	10	15	t	10	20
4	4	4	4	30	10			5	25	25	t	5	t
4	4	4	4					65	60				
4	4	4	4					10	30				
4	0	4	0					5	20	t	30	t	10
4	4	4	4					15	45				
4	4	4	4					15	60				
4	4	4	4					35	40				
4	4	4	4					40	60				
3	4	0	4					15	50				
4	2	2	0										
4	4	4	4					40	60				
4	4	4	4					25	60				
4	4	4	4										
4	4	4	4										
4	4	4	4					10	60				
4	0	4	0					15					
4	4	4	4					t	45				
4	0	4	1					15	30				
3	0	2	0					25	45				

Table 8. Continued.

Variety, selection, or species	C.I. number	Average type of seedling reaction to physiologic form number: 1	3	5	10	11	13	Per cent of cro[wn rust at] various locatio[ns]: Experiment, Georgia 1927a	Georgia 1928	Ames, Iowa 1926*	Ames, Iowa 1927a	Ames, Iowa 1929	Manhattan, Kansas 1929	A. & M., Mis[sissippi]
Red Algerian	2033	4	3	3	4	4	3					10	30	
do	2044	3	0	4	0	1	1					20	30	
do	2048	3	3	4	4	4	4					25	35	
Reids (57)		4	4	4	4	4	4	20	t	55	5	15	30	
Richland	787	4	4	4	4	4	4					30	60	
Red Rustproof	512	4	0	4	4	4	4		t	60	40	5	30	
do	518-5	4	0	4	4	4	4		t	60	25	5	30	
do	775	4	4	4	4	4	4	15	t	30	20	5	30	
do	844	4	0	4	0	0	0		5	55	55	10	30	
do	898	4	0	4	0	4	0		t	45	30	5	30	
do	921	4	0	4	0	4	0		2	65	55	5	35	
do	1008	4	0	4	4	4	4	15	2	25	30	10	40	
do	1059	4	0	3	0	4	0					15	45	
do	1079	4	0	4	0	4	0	15	t	20	25	25	25	
do	1089	4	0	4	0	4	0	15	2	40	40	5	10	
do	1450	4	4	4	4	4	4	70	20	60	50	50	50	
do	1571	4	0	4	0	4	0		1	30	40	5	35	
do	1850	4	0	4	0	4	0					5	30	
Red Rustproof Ga. 159	2808	4	0	4	0	4	0					5	50	
Red Rustproof Ga. 174	2809	4	0	4	0	4	0					10	45	
Ruakura Sel. (130)		4	4	4	3	4	4					15	45	
Ruakura	2025	4	0	4	[illegible]	0	0					25	65	
do	701	4	0	4	0	4	0		15	35	50	60	45	
do	1961	4	4	4	4	4	4	15	10	70	45	50	35	
Rustless	724	4	4	4	4	4	4					45	35	
Schoolmam	2057	4	4	4	4	4	4					5	10	
Scottish Chief	1699	4	4	4	4	4	4					20	50	
Seizure	1609	4	4	4	4	4	4					25	50	
Side Oat (87)		4	0	4	0	4	1	55	10	15	55	25	40	

age type of ing reaction siologic form number:				Per cent of crown rust infection observed at various locations during the years indicated									
				Experiment, Georgia		Ames, Iowa			Manhattan, Kansas	A. & M. College, Mississippi	Tifton, Georgia	Denton, Texas	Stillwater, Oklahoma
5	10	11	12	1927a	1928	1926*	1927a	1929	1929	1929	1929	1929	1929
5	4	4	3					10	30				
4	0	1	1					20	30				
4	4	4	4					25	35				
4	4	4	4	20	t	55	5	15	30	10	5	10	5
4	4	4	4					30	60				
4	4	4	4		t	60	40	5	30	10	10	t	5
4	4	4	4		t	60	25	5	30	10	5	t	5
4	4	4	4	15	t	30	20	5	30	15	5	t	5
4	0	0	0		5	55	55	10	30	5	4	5	5
4	0	4	0		t	45	30	5	30	25	5	5	t
4	0	4	0		2	65	55	5	35	5	5	5	10
4	4	4	4	15	3	25	30	10	40	10	5	5	10
3	0	4	0					15	45				
4	0	4	0	15	t	20	25	25	25	20	30	15	10
4	0	4	0	15	2	40	40	5	10	35	10	5	10
4	4	4	4	70	20	60	50	50	50	60		35	25
4	0	4	0		1	30	40	5	35	45	15	20	15
4	0	4	0					5	30	t	10	t	20
4	0	4	0					5	50				
4	0	4	0					10	45				
4	3	4	4					15	45				
4	1	0	0					25	65	80	40	20	50
4	0	4	0		15	65	60	60	45	80		30	35
4	4	4	4	15	10	70	45	50	35	95	30	35	20
4	4	4	4					45	35				
4	4	4	4					5	10				
4	4	4	4					20	50				
4	4	4	4					25	50				
4	0	4	1	55	10	15	55	25	40	15	5	20	20

Table 8. Continued.

Variety, selection, or species	C.I. number	Average type of seedling reaction to physiologic form number: 1	3	5	10	11	12	Per cent of crown ... various locations: Experiment Georgia 1927*	Georgia 1928	Ames, Iowa 1926*	Ames, Iowa 1927*	Ames, Iowa 1929	Manhattan Kansas 1929	A. & M. Missi...
Sidney (93)		4	1	4	1	4	1	15	10		75	25	45	
Silvermine	1013	4	4	4	4	4	4					25	50	
do	1894	4	4	4	4	4	4					20	35	
Sir Douglas Haig	1087	4	3	4	4	3	4					35	40	
Sixty Day	1687	4	4	4	4	4	4							
do	1906	4	4	4	4	4	4					15	60	
Sparrow Bill	1604	4	4	4	4	4	4					20	50	
Stable King (71)		4	2	4	4	4	4	50	10	20	30	35	45	
Standwell	1975	4	4	4	4	4	4					30		
State Pride	1154	4	4	4	4	4	4					20	50	
Storm King	1602	4	4	4	4	4	4					35	60	
Sunrise	982	4	0	4	0	4	0	15	t	15	5	5	5	
do	1799	4	0	4	0	4	0					t	15	
Sunrise (23)	982	4	0	4	0	0	0					5	10	
Sunrise (75)		4	0	4	4	4	4	30	1	15	t	15	20	
Sunrise Sel.	2769	4	0	4	0	4	0					30	30	
Svalof Victory	1145	4	4	4	4	4	4					50		
Swedish Select	1375	4	4	4	4	4	4					25	50	
Tabor	1777	4	4	4	4	4	4					5	40	
Tartar	991	4	4	4	4	4	4					35	45	
Tartar King	1599	4	4	4	4	4	4					40	60	
Tech	691	4	4	4	4	4	4							
do	947	4	4	4	4	4	4							
Terry	602	4	4	4	4	4	4					40	70	
Texas Red Rustproof	1817	4	0	4	0	4	0					5	45	
Tebalsk	1709	4	4	4	4	4	4					30	60	
Triumphal	1991	4	4	4	4	4	4					40	45	
Upright	2142	4	4	4	4	4	4					50		
Victor	803	4	4	4	4	4	4					50	60	

rage type of ling reaction ysiologic form number:				Experiment: Georgia		Ames, Iowa			Per cent of crown rust infection observed at various locations during the years indicated: Manhattan: Kansas	A. & M. College: Mississippi	Tifton: Georgia	Denton: Texas	Stillwater: Oklahoma
5	10	11	12	1927*	1928	1926*	1927*	1929	1929	1929	1929	1929	1929
4	1	4	1	15	10		75	25	45	30	t	5	10
4	4	4	4					25	50				
4	4	4	4					20	35				
4	4	3	4					35	40				
4	4	4	4										
4	4	4	4					15	60				
4	4	4	4					20	50				
4	4	4	4	50	10	20	30	35	45	30	15	30	15
4	4	4	4					30					
4	4	4	4					20	50				
4	4	4	4					35	60				
4	0	4	0	15	t	15	5	5	5	40	10	10	t
4	0	4	0					t	15				
4	0	0	0					5	10				
4	4	4	4	30	1	15	t	15	20	10	15	15	10
4	0	4	0					30	30				
4	4	4	4					50					
4	4	4	4					25	50				
4	4	4	4					5	40				
4	4	4	4					35	45				
4	4	4	4					40	60				
4	4	4	4										
4	4	4	4										
4	4	4	4					40	70				
4	0	4	0					5	45				
4	4	4	4					30	60				
4	4	4	4					40	45				
4	4	4	4					50					
4	4	4	4					60	60				

Table 8. Continued.

Variety, selection, or species	C.I. number	Average type of seedling reaction to physiologic form number: 1	3	5	10	11	12	Experiment: Georgia 1927*	Ames, Iowa 1928	1926*	1927*	1929	Per cent of crow[n rust at] various locatio[ns]: Manhattan: Kansas 1929	A. & M. Mis[s...]
Victoria	2401	0	0	0	I	0	0					0	t	
Victory	1145	4	4	4	4	4	4					20	45	
do	1985	4	4	4	4	4	4					15	35	
Warrigal (61)	2798	4	1	4	0	4	0		t	20	25	20	25	
Wayne	2567	4	4	4	4	4	4					20		
Volga (58)		4	1	4	4	4	4	75	t	30	25			
Wernich Golden	1746	4	4	4	4	4	4					10		
White Avalanche	1440	4	4	4	4	4	4					60		
White Bonanza	1686	4	4	4	4	4	4					25	60	
White Cross	2026	4	4	4	4	4	4							
White No. 1 (82)		4	4	4	4	4	4	50	10	20	25	40	40	
White Horse (85)		4	4	4	4	4	4	40	15	55	35	40	50	
White Ligowa (49)		4	0	4	0	4	0					10	10	
White Maine	1692	4	4	4	4	4	4					25	50	
White Russian	2460	0	4	4	0	0	0					5	5	
do	2461	4	4	4	4	4	4					t	5	
White Tartar	1640	4	4	4	4	4	4					30	60	
Winter Turf	1570	4	4	4	4	4	4					50		
Wisconsin Wonder	1645	4	4	4	4	4	4					60		
do	1894	4	4	4	4	4	4					15	50	
Wolverine	1531	4	4	4	4	4	4							
Worthy	1590	4	4	4	4	4	4					30		
Yarran (67)		4	4	4	4	4	4	50	t	70	45	35	60	
Yakutsk	498	4	4	4	4	4	4					50	70	
Zegehauer	1906	4	4	4	4	4	4					25	35	

*The data for 1926 and 1927 were collected by Dr. S.M. Dietz, Botany Department, Iowa State College, Ames, Iowa, and by L. D. Leach, Plant Pathology Department, California Agricultural Experiment Station, Davis, California.

**Numbers in parenthesis refer to 1929 row numbers at Ames, Iowa.

pe of ction e form		Experiment: Georgia		Ames, Iowa			Per cent of crown rust infection observed at various locations during the years indicated				
							Manhattan Kansas	A. & M. College Mississippi	Tifton Georgia	Denton Texas	Stillwater Oklahoma
11	12	1927*	1928	1926*	1927*	1929	1929	1929	1929	1929	1929
0	0					0	t				
4	4					20	45				
4	4					15	35				
4	0		t	20	35	20	25	5	t	t	t
4	4					20					
4	4	75	t	50	25			65	50	35	5
4	4					10					
4	4					60					
4	4					25	60				
4	4										
4	4	50	10	20	25	40	40	85	20	20	15
4	4	40	15	55	35	40	50	65	10	15	20
4	0					10	10	15	5	5	t
4	4					25	50				
0	0					5	5				
4	4					t	5				
4	4					30	50				
4	4					50					
4	4					60					
4	4					15	50				
4	4										
4	4					50					
4	4	50	t	70	45	35	60	30	50	45	20
4	4					50	70				
4	4					25	35				

l by Dr. S.H. Dietz, Botany Department,
Leach, Plant Pathology Department,
Davis, California.
numbers at Ames, Iowa.

A total of 316 varieties, selections, and species were inoculated with physiologic forms 1, 3, 5, 10, 11, and 12. Physiologic form 5 was again the most virulent form, only two varieties and one species being resistant to it. Victoria (C.I. 2401) and "Avena victoria" (C.I. 2764), apparently identical or similar varieties, were both completely resistant to form 5. _Avena strigosa glaberscens_ (C.I. 2630) was also completely resistant to form 5.

Sixteen varieties and selections, distributed among the following species: _Avena abbysinnica_, _A. brevis_, _A. byzantina_, _A. sativa_, _A. strigosa_, and _A. strigosa glaberscens_, were resistant to physiologic form 1. Next to form 5 this was the most virulent form tested.

Form 11 was of medium virulence. Thirty-one varieties, selections, and species were resistant to it. Ten of the varieties, selections, and species resistant to form 1 were also resistant to form 11.

Forms 3, 10, and 12 were comparatively weak forms. A total of 77, 76, and 74 varieties, selections, and species (including those in common) were, respectively, resistant to these forms. Forms 10 and 12 are very similar in their reaction on the 316 varieties, selections, and species tested. Two of the three varieties that are resistant to forms 1, 5, and 11 are also resistant to these two forms. The oat varieties belonging to the species *A. byzantina*, and especially the Red Rustproof varieties, are more resistant to form 3 than to the other five forms tested.

Only the two varieties Victoria (C.I. 2401) and "Avena victoria (C.I. 2674) were resistant to the six forms tested. *Avena strigosa glaberscens* (C.I. 2630) was resistant to all except form 10, and Calcutta x Cape (C.I. 2802) was resistant to all except form 5. Twenty varieties were resistant to four of the six forms used. Ninety-nine of the 316 varieties, selections, and species tested were resistant to one or more physiologic forms.

Because of the prevalence and wide distribution of form 5, it is difficult to correlate seedling reaction in the greenhouse with percentage of infection in the field. Those varieties and species that were resistant to form 5 were uniformly resistant in all field tests. Many varieties that were uniformly susceptible to all physiologic forms in the greenhouse show a low percentage of infection under certain field conditions. However, a low percentage of infection is apparently not always due to physiologic resistance. Usually the type of infection on these plants would be "completely susceptible", and when artificially inoculated with spores produced on themselves they would produce a larger percentage of infection, depending upon the amount of inoculum used. The resistance in such instances is probably functional instead of physiologic.

A number of the Red Rustproof varieties produced a relatively low percentage of infection under field conditions, while adjoining plants of another variety would produce a high percentage of infection. Numerous collections from the Red Rusproof and adjoining plants were all identified as either physiologic form 1 or 5. When Red Rustproof plants of these same varieties, of equal age were inoculated under greenhouse conditions with either form 1 or form 5 they produced a high percentage of infection. But under field conditions with an abundance of the same inoculum, they were apparently partially resistant, at least at certain locations. A variety would often show a low percentage of infection at one station and a high percentage of infection at another where the same forms were apparently present in equal abundance. It would seem that this is not true physiologic resistance and that it is affected by environmental conditions.

Certain varieties and species were outstanding for their resistance to crown rust under field conditions. Victoria (C.I. 2401) was observed during 1929 at Ames, Iowa, and at Manhattan, Kansas. At Manhattan, Kansas, it showed a trace of crown rust infection of type 0-1, while at Ames, Iowa, there was a trace of type 0. The unusual field resistance of Victoria (C.I. 2401), combined with its resistance to eight of the 13 physiologic forms described, should make this variety very valuable for hybridization and selection.

Avena strigosa glaberscens (C.I. 2630) showed a trace of type O infection at Ames, Iowa, and Manhattan, Kansas, during 1928. It was "completely resistant" or "immune" to all except one of the eight physiologic forms identified during 1929 and 1930.

Other varieties and species showing a comparatively low percentage of crown rust infection under field conditions were: White Russian (C.I. 2460 and 2461), Green Russian (C.I. 1040 and 2344), Glenn Innis (C.I. 980), Belar (C.I. 2760), Avena brevis (C.I. 2762), Red Rustproof (C.I. 1079 and 1089), Schoolmam (C.I. 2057), Sunrise (C.I. 982 and 1799), Algerian (C.I. 3579), and Nortex (C.I. 2382). While none of these varieties or species were equal to Victoria (C.I. 2401) in resistance during 1929, they were notable for their low percentage of infection as compared to the average commercial variety.

GRAMINEOUS HOST RANGE OF CERTAIN PHYSIOLOGIC FORMS

An attempt was made to determine the gramineous host range of physiologic forms 1, 3, 5, 10, 11, and 12. As many as possible of the various gramineous species that have been reported as hosts for Puccinia coronata were secured. The seedling reaction of each of these, and other species, to the above mentioned physiologic forms was determined.

The reaction of certain species of grass to a particular physiologic form of crown rust was not nearly as constant as was the reaction of oat varieties, selections, and species. Abnormal types of reaction, and much variation on individual plants and between different plants of the same species were observed.

In table 9 is given the reaction of 79 species, belonging to the tribes Agrostideae, Andropogoneae, Aveneae, Chlorideae, Festuceae, Hordeae, and Phalarideae, to each of the physiologic forms mentioned above.

Table 9. Reaction of certain species of grasses to six physiologic forms of *Puccinia coronata avenae*.

Species	Type of reaction to physiologic form number:											
	1		3		5		10		11		12	
	Range	Avg.	Range	Avg.	Range	Avg.	Range	Avg.	Range	Avg.	Range	Avg.
Achroydes aureum	2-4	4	2-4	4	2-4	4	2-4	4	2-4	4	2-4	4
Agropyron caninum	I-0	0-	I-0	0-	I-0	0-	I-0	0	I-0	0	I-0	0
Agropyron repens		I		I	I-0	I	I-0	0	I-0	0	I-0	0
Agropyron smithii		I		I		I		I		I		I
Agrostis alba		I		I		I		I		I		I
Agrostis exarata	I-0	I	I-0	0	I-0	I	I-0	0	I-0	0	I-0	0
Agrostis maritima		I		I		I		I		I		I
Agrostis palustris		I		I		I		I		I		I
Agrostis stolonifera		I		I		I		I		I		I
Agrostis thurberiana		I		I		I		I		I		I
Aira caespitosa		I		I		I		I		I		I
Alopecurus pratensis		I	I-0	0		I	I-0	0		I	I-0	I
Anthoxanthum aristatum	I-0	I	I-0	0	I-0	I	I-0	0	I-0	I	I-0	0
Anthoxanthum odoratum	0-4	3	0-3	2	0-4	3	0-3	2	0-3	2	0-3	2
Arrhenatherum elatius	I-0	I		I	I-0	I		I	I-0	I		I
Avena abyssinica (C.I. 2108-2)		4		4		4		4		4		4
do (C.I. 2108-9)		4		4		4		4		4		4
do (C.I. 2108-10)		4		4		4		4		4		4
Avena barbata (C.I. 2486)		4		0		4		0		4		0
do (C.I. 2487)		4		0		4		0		4		0
do (C.I. 2488)		4		4		4		4		4		4
Avena brevis (C.I. 1783)		0		0		4		4		4		4
Avena elatior		I		I		I		I		I		I
Avena nuda (C.I. 846)		4		4		4		4		4		4
Avena nuda brevis (C.I. 2465)		4		4		4		4		4		4
Avena sativa (C.I. 2053)		4		4		4		4		4		4
Avena sativa aristata (C.I. 2125)		4		4		4		4		4		4
Avena sativa aurea (C.I. 2127)		4		4		4		4		4		4
Avena sativa diffusa (C.I. 2138)		4		4		4		4		4		4
Avena sativa mutica (C.I. 2121)		4		4		4		4		4		4

Table 9. Continued.

Species	Type of reaction to physiologic form number: 1		3		5		10		11		12	
	Range	Avg.	Range	Avg.	Range	Avg.	Range	Avg.	Range	Avg.	Range	Avg.
Avena sativa mutica (C.I. 2122)		4		4		4		4		4		4
do (C.I. 2124)		4		4		4		4		4		4
Avena sativa vegetalis (C.I. 2137)		4		4		4		4		4		4
Avena strigosa (C.I. 1782)		4		0		3		4		4		4
Avena strigosa glaberscens (C.I. 2630)		0		0		0		4		0		I
Avena wiestii (C.I. 1994)		4		4		4		4		4		4
Beckmannia erucaeformis		I		I		I		I		I		I
Bromus ciliata		I		I		I		I		I		I
Bromus pumpellianus		I		I		I		I		I		I
Bromus richardsonii		I		I		I		I		I		I
Calamagrostis canadensis		I		I		I		I		I		I
Calamagrostis purpurascens		I		I		I		I		I		I
Capriola dactylon		I		I		I		I		I		I
Chloris gayana		I		I		I		I		I		I
Dactylis glomerata	0-4	3	0-1	0	0-1	0	I-0	0	I-0	0	I-0	0
Elymus canadensis		I		I		I		I		I		I
Festuca arundinacea		I		I		I		I		I		I
Festuca confinis		I		I		I		I		I		I
Festuca duriuscula		I		I		I		I		I		I
Festuca elatior	I-0	0	I-0	0	I-0	0	I-0	0	I-0	0	I-0	0
Festuca gigantea		I		I		I		I		I		I
Festuca obtusa		I		I		I		I		I		I
Festuca octoflora	2-4	3	2-4	3	2-4	3	0-3	2	2-4	3	0-3	2
Festuca ovina		I		I		I		I		I		I
Festuca rubra		I		I		I		I		I		I
Festuca rubra fallax		I		I		I		I		I		I
Festuca subulata		I		I		I		I		I		I
Festuca tenuifolia		I		I		I		I		I		I
Holcus halepensis		I		I		I		I		I		I
Hordeum distichon		I		I		I		I		I		I

Table 9. Concluded.

Species	Type of reaction to physiologic form number: 1		3		5		10		11		19	
	Range	Avg.	Range	Avg.	Range	Avg.	Range	Avg.	Range	Avg.	Range	Avg.
Hordeum jubatum		I		I		I		I		I		I
Hordeum vulgare		I		I		I		I		I		I
Lolium italicum		I		I		I		I		I	I-0	0
Lolium multiflorum		I		I		I		I		I		I
Lolium perenne		I	I-0	0		I		I		I	I-0	0
Lolium temulentum		I		I	I-0	0		I		I		I
Melica mutica		I		I		I		I		I	I-0	0
Notholcus lanatus		I		I	I-0	0		I		I		I
Phleum pratense	0-2	1	0-2	1	0-3	2	0-2	1	I-0	0	0-2	1
Poa annua	0-1	0	0-1	0	0-1	0	0-1	0	0-1	0	0-1	0
Poa arachnifera		I		I		I		I		I		I
Poa compressa		I		I		I		0		I		0
Poa nemoralis		I		I		I		I		I		I
Poa pratensis		I		I		I		I		I		I
Poa trivalis		I		I		I		I		I		I
Secale cereale		I		I		I		I		I		I
Sporobolus cryptandrus		I		I		I		I		I		I
Trisetum spicatum		I		I		I		I		I		I
Triticum vulgare		I		I		I		I		I		I

Forty of the 79 species were apparently immune to each of the six physiologic forms tested. Eighteen species (including 15 Avena species) gave a susceptible reaction to each of the six forms. Three of these (Achroyden aureum Boehmer, Anthoxanthum odoratum L., and Festuca octoflora Walt.) are wild grass species. Anthoxanthum odoratum and Festuca octoflora are common in occurrence throughout the United States, while Achroyden aureum is a native of Europe and is naturalized only in southern California. Dactylis glomerata L. gave a susceptible reaction to physiologic form 1, and minute uredinia were produced when it was inoculated with forms 3 and 5. The other forms (10, 11, and 12) produced only necrotic areas on this species. Minute uredinia were produced on Poa annua L. by each of the six physiologic forms used. Phleum pratense L. was quite variable in reaction. Uredinia were produced on this species by all forms, except form number 11 and repeated trials failed to produce uredinia when it was used. There was much variation in the production of chlorotic and necrotic areas on the different species. Apparently this type of infection is greatly influenced by environment and the age and condition of the host tissue. Newly developed leaves often gave a more susceptible reaction than older leaves.

It is evident from the data given in table 9 that certain of the species tested differ in their reaction when inoculated with different physiologic forms. However, outside of the Avena group, this evidence of physiologic specialization is slight. Before physiologic forms could be accurately differentiated using gramineous hosts, other than Avena, it would be necessary to secure pure lines of the various species.

Melhus, Dietz and Willey (47), using Puccinia coronata avenae, obtained normal infection on Alopecurus pratensis L. and Arrhenatherum elatius (L.) Mert. and Koch., while in the present investigations the maximum infection observed on these species was type O. It is possible that they were using a physiologic form to which these species were particularly susceptible, or it may be that the variance in results is due to variation within the two gramineous species.

The following species produced uredinia, when inoculated with some one or more of the six physiologic forms used:

Achroyden aureum	Avena sativa diffusa
Anthoxanthum odoratum	Avena sativa mutica
Avena abysinnica	Avena sativa vegetalis
Avena barbata	Avena strigosa
Avena brevis	Avena strigosa glaberscens
Avena nuda	Avena miestia
Avena nuda brevis	Dactylis glomerata
Avena sativa	Festuca octoflora
Avena sativa aristata	Phleum pratense
Avena sativa aurea	

DISCUSSION AND CONCLUSIONS

Forms 1, 3, and 5 seem to be common, occurring regularly from year to year. In addition there are evidently a number of comparatively rare forms of more or less infrequent occurrence. The source of these rare forms is not definitely known, but certain of them apparently originate on Rhamnus. If so, it is very probable that these and other new forms will continue to appear from year to year and it is altogether possible that new forms more virulent than form 5 will appear and that they will become widespread in distribution. However, the chances of such forms being produced are probably no greater for the future than they have been for the past.

Apparently the number of physiologic forms of crown rust present in certain localities is not constant from year to year. New forms seem to appear and certain of the old forms disappear. This is especially true in those regions where the alternate host functions. By collecting from different species of Rhamnus it may be possible to indefinitely continue the discovery of new physiologic forms.

The discovery of new differential hosts suggests the idea that they may also be a limiting factor in the discovery of new physiologic forms. It seems very probable that a more careful search would disclose additional differential hosts and that it might even be possible to sub-divide some of the physiologic forms now known. Also, the discovery of certain varieties possessing unusual resistance to the different physiologic forms and under field conditions, encourages further search for varieties resistant to all physiologic forms.

The varieties Victoria (C.I. 2401) and "Avena victoria" (C.I. 2764) are outstanding for their resistance to the eight physiologic forms secured during 1929 and 1930. Using resistant varieties of this type, it should be possible to produce, by hybridization, a hybrid selection resistant to crown rust, stem rust, loose smut, and covered smut. Such varieties as Iogold (C.I. 2329), Anthony (C.I. 2143), and Hajira (C.I. 1001) should furnish resistance to all physiologic forms of _Puccinia graminis avenae_ now present in the United States. While Markton (C.I. 2053), Black Mesdag (C.I. 1877), and other smut-resistant varieties and selections, should furnish resistance to loose and covered smut. Appropriate crosses between these varieties, and between their hybrids should be of great value both from the standpoint of producing high yielding, resistant selections, and for a study of the inheritance of resistance to these various diseases. By crossing Victoria (C.I. 2401) or "Avena victoria" (C.I. 2764) with the different differential hosts, it should also be possible to determine the number of factors involved in the inheritance of resistance to different physiologic forms of crown rust.

The investigation of physiologic specialization in crown rust should be continued, and apparently the relation of the alternate host to physiologic specialization and the production of new physiologic forms should be especially emphasized.

In Europe Klebahn (42) first divided *Puccinia coronata* Corda into two species *P. coronata* (Corda) Kleb. and *P. coronifera* Kleb. He believed that *Rhamnus frangula* acted as a differential host for these two species. Dietel (19) raised Barclay's (10) variety *himalensis* to a species rank, thereby adding a third species. The aecial stage of *Puccinia himalensis* (Barcl.) Diet. was on *Rhamnus dahurica*. Then Mühlethaler (49) added a fourth species, *Puccinia alpinae-coronata* Muhl. with an aecial stage on *Rhamnus purshiana*.

In America, Melhus, Dietz and Willey (47) and Dietz (22) have shown that certain species of Rhamnus act as differential hosts for the physiologic varieties of *Puccinia coronata* Corda.

The data secured in the present investigation indicates that certain species of Rhamnus may also act as differential hosts for physiologic forms of the physiologic variety *P. coronata avenae*.

Therefore, it is only logical to retain all physiologic varieties and forms of crown rust under the one morphologic species *Puccinia coronata* Corda. Physiologic specialization in the species is highly developed and is evident on both the Rhamnus and gramineous hosts.

SUMMARY

Two hundred forty-five cultures of *Puccinia coronata avenae* were obtained from 171 collections made during the years 1927, 1928, 1929, and 1930. One or the other of two uniform sets of 33 possible differential hosts were individually inoculated with each of these 245 cultures.

Thirteen physiologic forms were distinguished among these cultures by the differential reaction, of seedlings, of eight pure-line-selected: varieties, selections, and species of oats, and one species that was not pure-line-selected.

Physiologic form 5 was the most virulent form described, only the two varieties Victoria (C.I. 2401) and "Avena victoria" (C.I. 2764), and the species *Avena strigosa glaberscens* (C.I. 2630) being resistant to it. Forms 5, 1, and 3 were the most widely distributed forms, the former two predominating in the south.

Evidence is presented which indicates that certain physiologic forms may originate on certain species of Rhamnus.

The seedling reaction of 316 varieties, selections, and species to physiologic forms 1, 3, 5, 10, 11, and 12 is given. The percentage of crown rust on certain of these same varieties under field conditions at seven locations in the United States is also recorded.

The variety Victoria (C.I. 2401) was outstanding for its

resistance to eight physiologic forms collected during 1929 and 1930, and to epiphytotic of crown rust under field conditions at Ames, Iowa, and Manhattan, Kansas, during 1929.

A study of the gramineous host range of physiologic forms 1, 3, 5, 10, 11, and 12 is reported. The reaction of all species, outside the Avena group, to each of these physiologic forms is very similar.

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EXPLANATION OF PLATES

Plate I

Fig. 1. Muslin compartments in which all seedling plants were grown, to determine types of crown rust infection.

Fig. 2. Covered lamp chimneys used to retain crown rust cultures.

Plate II

Fig. 1. Tanks made of galvanized steel with false bottom and glass top used as inoculation chambers.

Fig. 2. Types of crown rust infection:

I. No macroscopic evidence of infection.

0. No uredinia formed, necrotic areas present.

1. Uredinia few, small, always in necrotic areas, also more or less necrotic areas produced without the development of uredinia.

2. Uredinia fairly abundant, small to medium size, always in necrotic or very chlorotic areas.

3. Uredinia abundant, medium in size, and surrounded by chlorotic areas.

4. Uredinia abundant, large, no necrosis or chlorosis immediately surrounding the uredinia.

Plate III

Fig. 1. *Puccinia coronata avenae* (Physiologic form 1)

1. Belar (C.I. 2760) - type 4.

7. Anthony (C.I. 2143) - type O.

8. Iowa 102 (C.I. 2464) - type O.

11. *Avena strigosa glaberscens* (C.I. 2630) - type O.

21. Victoria (C.I. 2401) - type O.

28. Markton (C.I. 2053) - type 4.

Fig. 2. Puccinia coronata avenae (Physiologic form 3).

1. Belar (C.I. 2760) - type 0.

7. Anthony (C.I. 2143) - type 4.

8. Iowa 102 (C.I. 2464) - type 4.

11. Avena strigosa glaberscens (C.I. 2630) - type 0.

21. Victoria (C.I. 2401) - type 0.

28. Markton (C.I. 2053) - type 4.

Plate IV.

Fig. 1. Puccinia coronata avenae (Physiologic form 5).

1. Belar (C.I. 2760) - type 4.

7. Anthony (C.I. 2143) - type 4.

8. Iowa 102 (C.I. 2464) - type 4.

11. Avena strigosa glaberscens (C.I. 2630) - type 0.

21. Victoria (C.I. 2401) - type 0.

28. Markton (C.I. 2053) - type 4.

Fig. 2. Puccinia coronata avenae (Physiologic form 6).

1. Belar (C.I. 2760) - type 3.

7. Anthony (C.I. 2143) - type 4.

8. Iowa 102 (C.I. 2464) - type 0.

11. Avena strigosa glaberscens (C.I. 2630) - type 0.

21. Victoria (C.I. 2401) - type 0.

28. Markton (C.I. 2053) - type 4.

Plate V

Fig. 1. *Puccinia coronata avenae* (Physiologic form 10).

1. Belar (C.I. 2760) - type O.

7. Anthony (C.I. 2143) - type O.

8. Iowa 102 (C.I. 2464) - type O.

11. *Avena strigosa glaberscens* (C.I. 2630) - type 4.

21. Victoria (C.I. 2401) - type I.

28. Markton (C.I. 2053) - type 4.

Fig. 2. *Puccinia coronata avenae* (Physiologic form 11).

1. Belar (C.I. 2760) - type 4.

7. Anthony (C.I. 2143) - type O.

8. Iowa 102 (C.I. 2464) - type 4.

11. *Avena strigosa glaberscens* (C.I. 2630) - type O.

21. Victoria (C.I. 2401) - type O.

28. Markton (C.I. 2053) - type 4.

Plate VI

Fig. 1. *Puccinia coronata avenae* (Physiologic form 12)

1. Belar (C.I, 2760) - type O.

7. Anthony (C.I. 2143) - type O.

8. Iowa 102 (C.I. 2464) - type O.

11. *Avena strigosa glaberscens* (C.I. 2630) - type I.

21. Victoria (C.I. 2401) - type I.

28. Markton (C.I. 2053) - type 4.

Fig. 2. Puccinia coronata avenae (Physiologic form 13).

1. Belar (C.I. 2760) - type 0.

7. Anthony (C.I. 2143) - type 1.

8. Iowa 102 (C.I. 2464) - type 4.

11. Avena strigosa glaberscens (C.I. 2630) - type 0.

21. Victoria (C.I. 2401) - type 0.

28. Markton (C.I. 2053) - type 4.

Plate VII

Teliospore formation of physiologic forms 3 and 5 on seedling plants from two panicles of oats. All infection 16 days old and produced under identical conditions.

1. Fulghum (C.I. 650-203) - abundant telia formation, physiologic form 3.

2. Fulghum (C.I. 650-203) - abundant uredinia formation (no telia), physiologic form 5.

3. D.A.C. # 10 (C.I. 2829) - abundant telia formation, physiologic form 3.

4. D.A.C. # 10 (C.I. 2829) - abundant uredinia formation (no telia), physiologic form 5.

Plate I

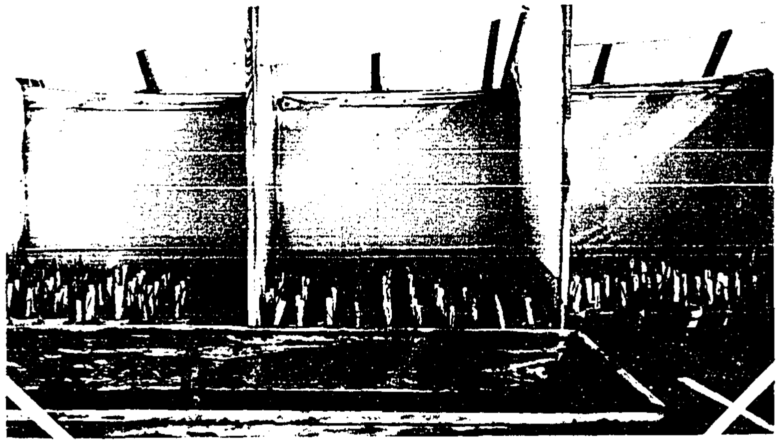

Figure 1

Figure 2

Plate II

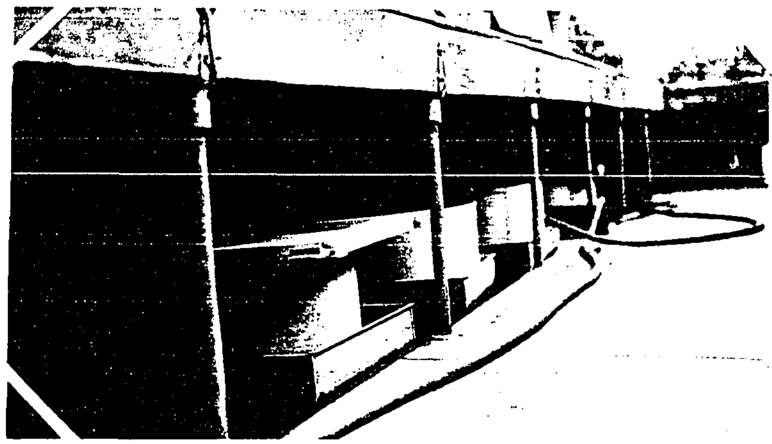

Figure 1

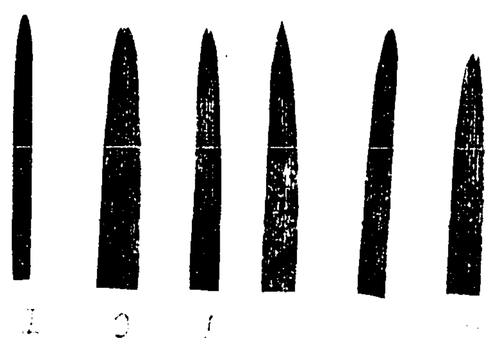

Figure 2

Plate III

Figure 1

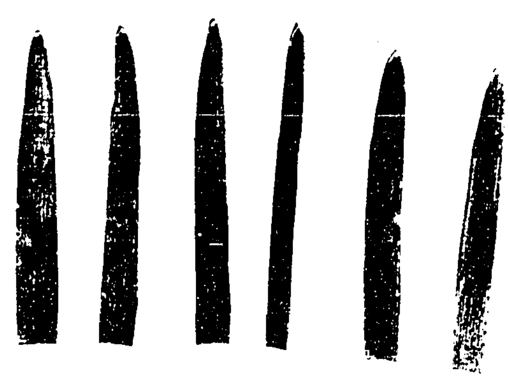

Figure 2

Plate IV

Figure 1

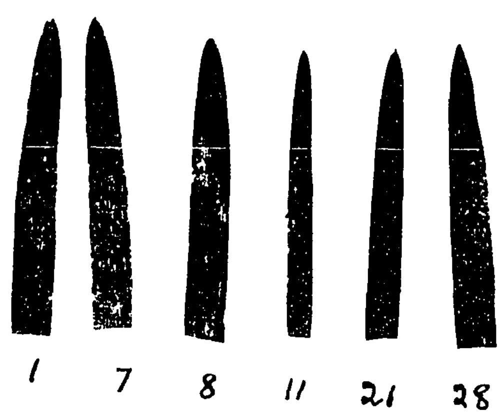

Figure 2

Plate V

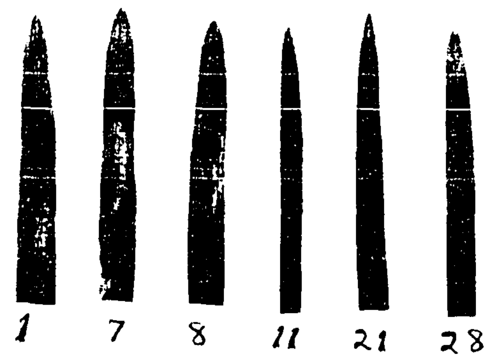

Figure 1

Figure 2

Plate VI

Figure 1

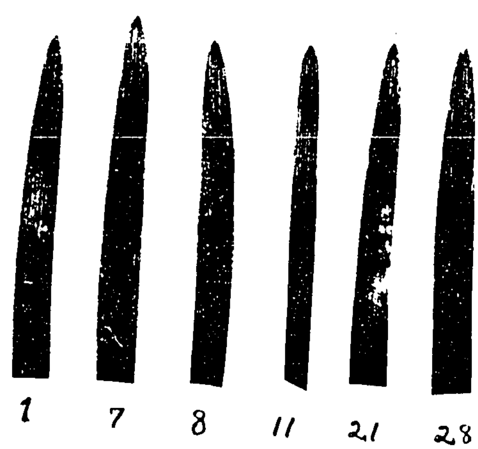

Figure 2

Plate VII

1

2

3

4