INHERITANCE OF RESISTANCE IN WHEAT TO STEM RUST - RACE 15B

by

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INTRODUCTION

For the areas where wheat stem rust (*Puccinia graminis tritici*, Eriks. and Henn.) has been, and may be, prevalent, the importance of rust resistant varieties cannot be over-emphasized. Although severe epidemics have occurred only periodically, yet the disease has been present every year with varying amounts of damage. According to Greaney (9) the average annual loss in wheat between 1925 and 1935 for Manitoba and Saskatchewan was calculated to be 35.5 million bushels, constituting a cash loss through reduction in yield alone of 30.8 million dollars for each year of this period. Losses for specific years have at times reached gigantic proportions. Craigie (4) stated that in Western Canada in 1916 there was a loss of 170 million dollars from reduction in wheat production and of 64 million dollars from reduction in grade, making a total monetary loss of 234 million dollars.

The development of rust resistant varieties has been invaluable in decreasing losses. In the development of these varieties, the plant breeder has to take into consideration, among other factors, physiologic specialization of rust and physiologic resistance of parent material.

There are many known physiologic races of stem rust. Recently, biotypes in some of these races have been identified. New physiologic races or biotypes may arise on the barberry through hybridization between existing races (Garcia-Rada *et al* (6)).

Biotype B of Race 15 has recently been identified in several stem rust collections from different parts of the United States, but has

not as yet been isolated in Canada. Hart (14) reports Race 15B as being virulent under Minnesota conditions and many of the varieties used there as rust resistant parents are moderately to highly susceptible to it. She emphasizes the possible economic danger of this Race:

> "If biotype B of race 15 once becomes established in the Mississippi Valley, which is not at all improbable, it may be very destructive to many of the new winter-wheat hybrids, to all spring-wheat varieties now grown commercially, to most of the newer varieties and hybrids of hard red spring wheat, and to the new durum varieties. Susceptible hosts would be well distributed over the entire central and northern parts of the Mississippi Valley. With an increase in inoculum of race 15B and with a wide distribution of susceptible wheats, it would be necessary to rely chiefly on environmental factors for the prevention of future stem-rust epidemics until resistance to race 15B could be incorporated into other desirable wheats."

Craigie (5) points out that there is a similarity year by year in the amount of infection and in the physiologic races present in Western Canada and in the Northern Mississippi Valley. This, as he states, indicates strongly that the bulk of the wind-borne inoculum originates in the latter area.

In view of the situation as discussed above, the present study was undertaken to determine the mode of inheritance of resistance in the seedling stage to Race 15B of some of the parental varieties currently used by the Dominion Laboratory of Cereal Breeding and the Dominion Laboratory of Plant Pathology, Winnipeg, Manitoba.

REVIEW OF LITERATURE

Owing to its recent discovery, very little information is available concerning biotype B of Race 15.

Stakman et al. (28) mention that two biotypes of Race 15 have been found, one of which, differentiated by Rival, attacks certain Kenya wheats and Thatcher. Loegering and Stakman (19) refer to the two biotypes as Races 15A and 15B. Race 15A has been found in Japan and the United States while 15B commonly occurs in South America and is not uncommon in the United States.

Literature from South America indicates that the South American Race 15 differs from Race 15 described by Stakman and Levine (27), but biotypes are not mentioned.

Sixty varieties of wheat were sent to Peru from the United States and studied under field conditions by Abbott (1), and all were found to be very susceptible to stem rust. The physiologic form mainly responsible for infection fitted the description of Race 15 except that the infection on Khapli was heavy instead of light and it therefore was not considered as identical with Race 15.

Garcia-Rada et al. (6) isolated Race 189 in South America, describing it as the most virulent of all races. They suggest that it might have been the Race described by Abbott (1). However, Yadlin (34) and Vallega (29) report Race 15 as being the most prevalent Race in South America.

Watson (32) using inoculum of Race 15 from three sources (Brazil, Japan, and the United States) found differences in infection type. The inoculum from Japan and the United States produced one type of

reaction whereas the inoculum from Brazil, more virulent, produced a different reaction.

Hart (13) found Triticum timopheevi, Zhuk., susceptible in the seedling stage to 15B which, in view of the findings of Newton et al. (24), indicates that 15B is different from the Canadian Race 15.

The problem confronting plant breeders with the advent of 15B is discussed by several authors. Hart (14, 15) working with recently developed rust resistant varieties and hybrids which include Apex, Renown, Regent, McMurachy, H-44-24 derivatives and Iumillo derivatives, found that no variety in this group had seedling resistance to 15B. In the mature plant stage, most of the varieties and hybrids were moderately to highly susceptible.

Ausemus (2) reports that Hope, Thatcher, some Kenya varieties and T. timopheevi are susceptible to 15B in both the seedling and mature plant stage. Red Egyptian, on the other hand, has moderate resistance. Loegering (20) also mentions Red Egyptian as showing some resistance to 15B.

The resistance or susceptibility of varieties to Race 15B, as reviewed above, need not be considered as an indication of what will happen under the climatic conditions of Manitoba. Johnson and Newton (18) have pointed out occasional differences in results obtained at St. Paul, Minnesota, and at Winnipeg, Manitoba. In the same paper they showed that mature plant resistance may break down under conditions of high temperature (about 80 degrees F.). The response of seedlings in most cases resembled that of the mature plants with respect to the effect of temperature.

Breakdown in resistance due to high temperature was also reported by Newton et al. (24) and Peterson et al. (25).

That a variety may vary somewhat from time to time in its reaction to a particular physiologic race, due to changes in enviromental conditions such as light, temperature, and humidity, was shown by Newton et al. (23), Hart and Forbes (11), Hart and Zaleski (12), and Watson (31).

The work of Cassell (3) as reported by Watson (33) has demonstrated very clearly that certain races of stem rust are aggressive at high temperatures, others thrive on their hosts at low temperatures, while still others seem to be adapted to a wide range of temperature conditions.

The effect of enviroment on the percentage of infection may be of considerable importance. Under greenhouse conditions, even with artificial illumination, Neatby (21) found that infection sometimes failed to take place on all seedlings. Hart and Forbes (11) obtained a higher degree of infection in light than in darkness but in no case did they obtain 100 per cent infection. They used seven varieties of wheat and two races of stem rust, obtaining a range in percentage of infection from 54.8 per cent to 90.1 per cent under light.

Watson (32) was able to obtain satisfactory segregation for resistant, segregating, and susceptible F_3 lines under greenhouse conditions.

Reference to resistance or susceptibility of the varieties used in this thesis (as listed under "Materials and Methods") will now be briefly reviewed.

Newton et al. (24) and Peterson et al. (25) describe McMurachy and Kenya as practically immune, except when grown under abnormally high

temperatures, to all physiologic races of stem rust to which the two varieties had been exposed (about 20 races). This applied to both seedling and mature plants.

Yadlin (34), testing a number of varieties of wheat with a mixture of Chilean physiologic races in which the South American Race 15 was predominant, found Red Egyptian and McMurachy to be immune while Kenya and Hope were susceptible. H-44-24 was not included in the test but the reaction of Hope may be taken as indicative of that of H-44-24.

Johnson and Newton (18), in a greenhouse study, found McMurachy, Kenya, Red Egyptian, N.A. 95, and Iumillo either immune or resistant to Races 15, 29, and 56 in both seedling and the mature plant stage. Minor was found to be more susceptible in the seedling stage than in the mature plant stage. Marquis was susceptible in every test.

Goulden et al. (7), in a study of an H-44-24 x Marquis cross, showed that mature plant resistance was inherited independantly of seedling resistance. H-44-24 was susceptible in the seedling stage and resistant in the mature plant stage.

In general, seedling resistance is normally indicative of resistance in the fully grown plant. The correlation between the two is borne out by the findings of Harrington and Smith (10), Neatby (22), Waddell (30), and Peterson et al. (25). On the other hand, seedling susceptibility may not necessarily be indicative of mature plant reaction. Mature plant resistance has been demonstrated by Goulden et al. (7), Hayes and Aamodt (16), Hayes et al. (17), and Neatby (21).

MATERIALS AND METHODS

Varieties and Hybrids

The varieties of wheat (Triticum vulgare, Vill.) and the hybrids used were a part of material grown at the Dominion Laboratory of Cereal Breeding, Winnipeg, by Peterson et al* in a study on the inheritance of resistance to races of stem rust commonly occurring in Canada.

The varieties selected as parents are listed with their Canadian Accession Numbers and the Accession Numbers of the Dominion Laboratory of Cereal Breeding.

Variety 'Thesis designation'	C.A.N.**	R.L.No.***
Kenya	1961	1373
McMurachy	1913	1313
Marquis	1396	84
Red Egyptian	3533	2061
Minor	3534	2058
N.A. 95	3532	2063
H-44-24	1352	229
R.L. 1544	3539	1544

Kenya is one of five Kenya varieties received in 1934 from the Department of Agriculture at Nairobi, Kenya Colony. It is described as rust resistant. McMurachy was received in 1935 from Mr. M. S. J. McMurachy,

* Unpublished data by R. F. Peterson, A. B. Masson and L. H. J. Shebeski, a brief review of which is given under the section "Previous Studies".

** Canadian Accession Number.

*** Dominion Laboratory of Cereal Breeding Accession Number.