Additive Genes in Wheat Conditioning Resistance to Stripe Rust

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ABSTRACT

Wheat selections containing various additive genes obtained from P.I. 178383 and Itana wheats showed similar levels of resistance to 11 cultures of *Puccinia striiformis* known to possess different genes for virulence. Moro wheat, which contains only the major gene from P.I. 178383, was susceptible to one isolate, but other wheat cultivars and selections with minor additive genes from P.I. 178383 and Itana were intermediate or resistant in reaction to this isolate as well as to all others. The possibility of utilizing minor additive genes in developing long-lasting resistance to stripe rust is discussed. Phytopathology 60:1146-1147.

Additional key words: Puccinia striiformis, specificity vs. nonspecificity.

In earlier work (2) it was determined that P.I. 178383 wheat contained one major and several minor genes conditioning reaction to Bozeman isolate B-I1 (ATCC PR No. 35) of *Puccinia striiformis* West. The major gene conditioned an infection type oo but was not completely dominant, as heterozygotes in some backgrounds conditioned infection type 0-. The major gene was not temp-sensitive. The minor recessive genes were additive, and conferred greatest resistance at relatively high temp regimes. By inoculation, selection, continuous selfing, and diallel cross-analysis at various temp regimes, lines of P.I. 178383 × Itana were isolated which contained one, two and three minor genes (5, 6). These wheat lines containing one, two, and three minor genes conditioned mean infection types 2, 0, and 0- at 15/24 C (night/day) and 3, 2, and 0 at 2/18 C (night/day), respectively, when inoculated with rust culture B-I1. Methods of inoculation, incubation, and rust rating have been previously described (2, 4).

In determining the specificity or nonspecificity of the minor genes, the host lines were inoculated with seven monospore rust cultures and four nonmonospore cultures known to possess different genes for virulence. The rust cultures were collected at various locations in Washington, Oregon, Idaho, Utah, and Montana.

All 11 isolates produced infection types on the minor gene lines similar to those described above for isolate B-I1. Of particular interest were the reactions with isolate BF-Mo from Bonner's Ferry, Idaho, with known capability to overcome the major gene from P.I. 178383 (1). Figure 1 illustrates infection types obtained on Moro, Crest, P.I. 178383, and a wheat line derived from P.I. 178383 × Itana following inoculation with BF-Mo. Moro contains only the major resistance gene from P.I. 178383, Crest and P.I. 178383 contain the major plus some minors, and the P.I. 178383 × Itana line contains only three minor genes. Moro is susceptible, Crest and P.I. 178383 are intermediate, and the P.I. 178383 × Itana line is resistant. The lower infection type on this latter line in comparison to P.I. 178383 indicates that one minor gene was contributed by Itana. Itana has been susceptible (infection types 4, 3) at both temp regimes to all stripe rust isolates evaluated to date.

The minor gene lines from P.I. 178383 × Itana have been evaluated in the field under local epidemic conditions for 2 years, and have shown similar infection types to those obtained on seedlings at simulated field temp. The line containing only one detectable minor gene may eventually develop infection type 3 in the field, but severity rating increases at a much slower rate than for completely susceptible checks. Preliminary trials also indicate that the grain yield of this line is not noticeably reduced by stripe rust, while susceptible checks selected from the same cross were reduced more than 50% in yield.

It is interesting that so many wheat cultivars possess minor genes effective against stripe rust. In this research as well as that of Pope's (3), a number of cultivars, such as Itana, appear susceptible but contribute

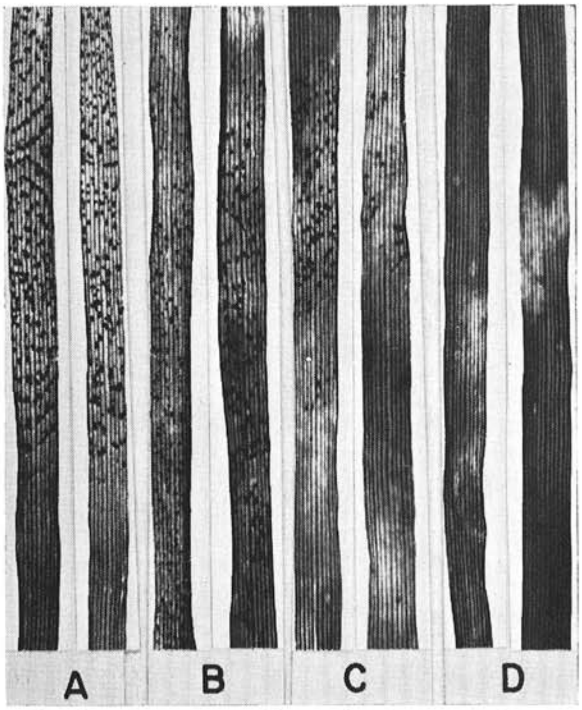

Fig. 1. Minor gene resistance in wheat to isolate BF-Mo of *Puccinia striiformis* evaluated at 2/18 C. Moro contains no minor genes; the others do. **A)** Infection types 4, 3 on Moro; **B)** type 3- on Crest; **C)** types 2, 1 on P.I. 178383; **D)** type 1-, 0 on P.I. 178383 × Itana. Isolate BF-Mo can overcome the major resistance gene from P.I. 178383 present in A, B, and C. D adds minor genes from P.I. 178383 and Itana.

additive genes for resistance. A certain gene background may be required before minor genes for resistance can be detected, and detection may also require evaluation at specific environmental regimes. Pope (3) considers these genes not as "genes for resistance" but as genes controlling functions in a gene complex that confers resistance. In our work with candidate differential cultivars for determining gene virulence pools, it has been repeatedly noted that a wheat cultivar may have a major gene effective against a specific rust culture, and additionally contain minor genes with additive effects against the specific culture and many other rust cultures.

The results to date indicate that the minor additive genes are nonspecific in action, but this holds for any resistance gene until new genes for virulence appear in the pathogen. The wheat cultivar, Moro, containing only a major resistance gene from P.I. 178383, remained resistant for only 3 years. Cheyenne and Rego wheats, on the other hand, contain minor additive genes which have resulted in an acceptable level of stripe rust resistance since 1960 when the disease became epidemic in the area.

At any rate, minor additive genes should result in a longer-lasting resistance. They have been easier to use in development of stripe rust-resistant wheat cultivars than have a number of major genes because it has not been necessary to inoculate candidate selections with an array of different physiologic races. Furthermore, in the absence of major epistatic genes, the effect of each minor additive gene can be detected by judicious manipulation of controlled environment, or by consideration of the environment in evaluations made in the field.

If the fungus does mutate to overcome minor gene resistance, assuming stepwise mutation of the pathogen, there would be a stepwise but gradual change toward susceptibility.

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