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Relative Importance of Components Affecting the Leaf Rust Progress Curve in Wheat

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Summary. The relative importance of various components (latent period, uredium area, infectious period, infectibility, sporulation and weather) affecting the progress of leaf rust (*Puccinia recondita*) in wheat, in the field, was determined by calculating the effect of equivalent changes in the individual components. The effect was calculated in terms of the period of delay in the epidemic reaching 100 per cent severity of leaf rust. Only four components viz., latent period, infectibility, sporulation and weather were found to be important. Further, it was found that these four components were equally important and that they collectively determined the rate of progress of leaf rust in an additive manner.

Key words: Slow-rusting resistance – Horizontal resistance – Component analysis

Introduction

Consequent to renewed interest in horizontal resistance during recent years, several reports have appeared on component analysis of slow-rusting resistance in cereals (Reviews by Parlevliet 1979; Kulkarni and Chopra 1980a). Recognizing that the contribution of a component of slow-rusting to an epidemic cannot be determined by a simple measurement of its magnitude in monocyclic infection experiments, Shaner and Hess (1978) developed equations to predict the effect of any given set of resistance components on the course of disease progress in the field. Using their equations, we measured the relative importance of different variables determining the course of an epidemic and the results are presented here.

Materials and Methods

The cultivar 'Kharchia Local' does not possess any vertical gene for resistance to the Indian virulences of *Puccinia recondita* Rob. ex. Desm. and has also very little horizontal resistance. Thus, it is extremely susceptible to the leaf rust fungus, and is, therefore, routinely used as a 'spreader' variety for creating artificial epidemics in the field. The various components required to generate a hypothetical leaf rust progress curve, using the equations of Shaner and Hess (1978), were determined on adult plants of 'Kharchia Local', in monocyclic infection experiments using race 77A of *Puccinia recondita*. The progress of leaf rust on 'Kharchia Local' in the field was also measured. The details have been published elsewhere (Kulkarni and Chopra 1980; Kulkarni et al. 1981[1]). The values of different components are given in Table 1.

Table 1. Values of the different components used for generating the hypothetical leaf rust progress curve of the cultivar 'Kharchia Local'

Component	Value	Component	Value
P_p	0.389	n	20
P_{p+1}	0.303	S	2,413
P_{p+2}	0.206	λ	0.0028
P_{p+3}	0.065	a	0.879
P_{p+4}	0.037	ν	0.120
p	9	α	10,000
m	13	I_0	10

Pp = Probability of an infection that occured on the $(i-j)$th day erupting on ith day. p = Minimum number of days after infection when a uredium appears. m = Maximum number of days after infection when all infections that occur on any given day have erupted. n = Infectious period in days. S = Number of spores produced per uredium per day. λ = The proportion of spore "hits" estimated from field data. a = Area per infection site in square millimeters derived by dividing mean uredium size by 0.34. ν = The proportion of spores on potential infection sites that successfully infect. α = Total leaf blade area in square millimeters, arbitrarily chosen. I_0 = Number of initial infections, arbitrarily chosen.

1 The components in this reference were estimated on adult plants and not on seedlings. The mistake in the paper arises from an oversight

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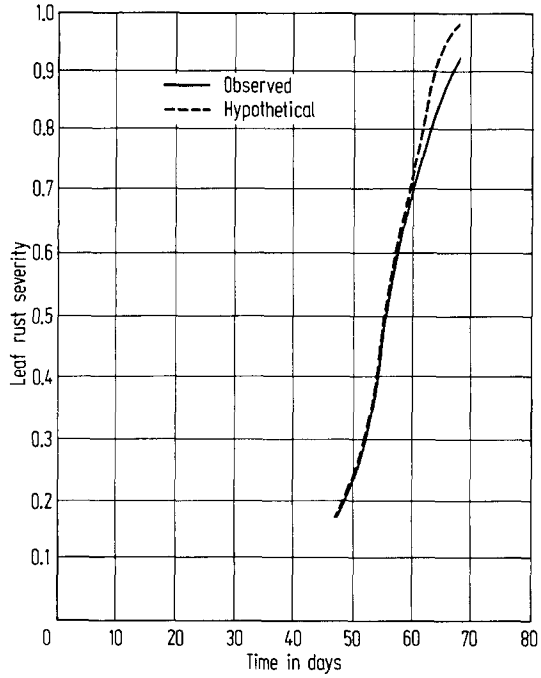

Fig. 1. Observed and hypothetical progress of leaf rust on the cultivar 'Kharchia local'

The component (λ) is the ratio of the total number of spores that actually land on leaf blades to the total number of spores produced. It is a function of weather and total leaf canopy area. The total leaf canopy area is quantified by the parameter (α) and is constant during the course of the epidemic since leaf rust does not appear until flag leaves have appeared. Of the weather factors that affect the value of (λ), wind determines the total number of spores that actually land on leaf blades; temperature and relative humidity influence the total number of spores produced through their effects on infectibility, latent period, sporulation and infectious period. The component (λ) is thus mainly a function of weather.

The component infectibility (ν) was not determined experimentally; its average value obtained by Shaner et al (1978) was used. Infectious period (n), leaf blade area (α) and number of initial infections (I_0) were arbitrarily chosen as 20 days, 10,000 mm^2 and 10 respectively. With these values, the hypothetical leaf rust progress curve agreed very closely with the observed one (Fig. 1). The hypothetical leaf rust severity was found to reach 100 per cent on the 77th day. (In Fig. 1, the leaf rust severities have been plotted only for the period during which actual leaf rust severity on 'Kharchia Local' was recorded in the field.)

To determine the magnitude of the effect of each component on the progress of leaf rust in the field, resistance was increased by increasing or decreasing (as the case was), at a time, each of the components by 1/10th of their respective values and the number of days taken to reach 100 per cent severity estimated. To determine whether the components contributed together in an additive manner or not, only such components as were found to be important were studied in different combinations. All the computations were done on B4700 computer.

Results and Discussion

Infectious period and uredium area were found to be relatively unimportant (Table 2). The finding that infectious period is unimportant supports Vanderplank's (1968) view. Uredium area appears to be important only with respect to the number of spores it produces.

It was interesting to note that with equivalent changes in latent period, sporulation (S), infectibility (ν) and weather (λ), there was an almost equivalent delay in the epidemic (barring one day greater delay in the case of latent period. This difference would be magnified and might become more important at higher levels of resistance). Therefore, it appears that all four components are equally important and that they collectively determine the rate of progress of disease in the field.

Even though the component infectibility (ν) has been found to be as important as any other important component it may, perhaps, be difficult to improve slow-rusting resistance by breeding for this component. This is because not much genetic variability can be expected for this component as slow-rusting resistance is of the non-hypersensitive type. Shaner and Hess (1978), in fact, found very little varietal differences for this component.

The finding that weather (λ) is as important as any of the important components of host resistance is interesting. Discussing the disease triangle, i.e. host-pathogen-environment interactions, Vanderplank (1968) stated that coupled with the concept of the

Table 2. Delay in reaching 100 per cent severity in the epidemic (number of days), brought about by manipulating various components

Component(s) manipulated	Delay in days to reach 100% severity	Deviation from additivity
(1) Infectious period (n)	1	–
(2) Uredium area (a)	0	–
(3) Latent period (LP)	5	–
(4) Sporulation (S)	4	–
(5) Weather (λ)	4	–
(6) Infectibility (ν)	4	–
(7) LP, S	9	0
(8) LP, λ	10	1
(9) LP, ν	9	0
(10) S, λ	9	1
(11) S, ν	8	0
(12) λ, ν	9	1
(13) LP, S, λ	15	2
(14) LP, S, ν	14	1
(15) LP, λ, ν	15	2
(16) S, λ, ν	15	3
(17) LP, S, λ, ν	21	4

disease triangle is the concept of equivalence of the effects of changes in the host, pathogen and environment. In other words, equivalent changes in the host, pathogen or environment produce the same effects. The equivalence of the effects of changes in the host and environment is further illustrated by the results of this study.

The effects of the various components in different combinations show that the components generally act in an additive manner (Table 2). Small deviations from additivity have, however, been found with some combinations of the components. Since it was not possible to determine the exact period of delay in the epidemic to reach 100 per cent severity of leaf-rust, the actual effect of each component may be slightly greater than the values given in Table 1 and the cumulative effect of these undetermined fractions might have partly been responsible for the deviation from additivity observed in some combinations of the components. This may, partly, also explain the observation that the deviation from additivity increased with the increase in the number of components in the combination.

Earlier, using step-wise linear multiple regression analysis, Kulkarni and Chopra (1980) found that sporulation was the most important component of slow-rusting resistance. Uredium area and latent period were found to be relatively unimportant. The present study gives a different picture (with regard to the significance of latent period). This is understandable because in regression analysis, a linear relationship between the causes and the effect is assumed, which is, however, not valid in the case of slow-rusting resistance and its components. It was because of this reason that the equations for slow rusting resistance were developed by Shaner and Hess (1978) and the results of our study bring this out clearly. Therefore, it may not always be correct to directly extend the results of correlation analysis of the components, estimated in monocyclic infection experiments in greenhouses, to field conditions. However, since the components of host resistance are generally closely associated (Kulkarni and Chopra 1980) indirect selection for slow-rusting resistance through any of the three important host-resistance components should be effective.

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