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RELATIONSHIP BETWEEN THE INCIDENCE AND SEVERITY OF *COLLETOTRICHUM GLOEOSPORIOIDES* LEAF DISEASE IN *HEVEA BRASILIENSIS*

by

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SUMMARY

Incidence and severity of the *Colletotrichum gloeosporioides* leaf disease in *Hevea* clones grown in four rubber growing districts were surveyed on three seasons and the relationship between these two factors was examined. The overall incidence and severity varied in different environments, but the relative degree of resistance of the clones was not markedly affected by the environmental differences. The relationship between incidence and severity was linear when the plants were less affected by the disease while a curvilinear trend was evident in susceptible clones when they were heavily infected. Incidence proved to be a better index for discriminating clones for their susceptibility in the field than severity; but comparison of the computed ratios between incidence and severity was found to be a more reliable procedure than when they were treated independently.

INTRODUCTION

Since the first record of the *Colletotrichum gloeosporioides* leaf disease in 1905 (Petch, 1921) several field observations have been carried out to assess the incidence of the disease. Disease incidence has been positively related to high rainfall and elevation, and the clone PB 86 has been noted to be a very susceptible one (Wimalajeewa, 1965; Wimalajeewa and Lloyd, 1963). However, these surveys did not include recently bred clones. Subsequent field studies (Liyanage, 1976 and 1977) showed the existence of differential susceptibility under different environmental conditions.

In practice, two parameters, disease incidence (I) and disease severity (S) are expressed independently though they seem to be related to each other. For a meaningful understanding of the field susceptibility of the clones, relationship between incidence and severity has to be examined. In this study, while I and S of *Hevea* clones grown in different rubber growing areas are considered independently investigations are made on the relationship between incidence and severity.

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MATERIALS AND METHODS

Assessment of incidence and severity in different locations

Four estates *viz.* Eladuwa, Elston, Hatbawa and Peenkande respectively in Kalutara, Kelani Valley, Kegalle and Ratnapura districts were selected for the survey. Assessments were carried out on one-to two-year-old trees from the clones RRIC 100, RRIC 101, RRIC 102, RRIC 103, RRIC 104, RRIC 105, RRIC 107, RRIC 118, RRIM 600, PB 86 and GT 1 planted in ten-tree plots which were replicated twenty times in randomized block design.Two trees were selected at random from each plot for the assessment and only the leaves of the top 2 whorls were assessed. They were visually classified on a scale of one to six, respectively for 0%, 0-20%, 21-40% 41 - 60%, 61 - 80% and 81 - 100% of the leaf area infected for computation of S. When the whorls showed complete defoliation it was considered to be 100% infected. To estimate I the total number of leaves and the total number of diseased leaves in the 2 whorls were recorded. Assessments were made in October-November 1979; May - June, 1980 and November - December, 1980 about 2 weeks after, the rain had started.

Disease incidence was calculated by dividing the number of infected leaves by the total number of leaves and expressed as a percentage. For the estimation of S the sum of percentage area damaged by the pathogen was divided by the total number of leaves which included both infected and non-infected.

Spearman's Rank Correlation (Snedecor and Cochran, 1980) was employed to determine as to what extent the ratio between the index of resistance and susceptibility of different clones corresponded in different seasons and different locations in respect of each of the indices of incidence and severity. Two locations, Hatbawa where the incidence was generally low and Peenkande where the incidence was generally high were selected. Data obtained from these two locations in two seasons *viz.* May - June, 1980; which had low incidence and November-December, 1980 which had high incidence were considered for analysis. The selection of locations and seasons were made in order to have a better contrast of the computed ratio.

Relationship between incidence and severity

For determination of the relationship between I and S of the disease, data was considered from 2 resistant clones RRIC 105 and RRIC 118 and 2 susceptible clones RRIC 101 and GT 1 from each of the two locations, Hatbawa and Peenkande and in two different seasons, May - June, 1980 and November-December, 1980. The regression analysis was carried out by using the linear regression model $S = a + bI$ where S=disease severity, I =disease incidence and a and b=regression parameters.

In addition to the linear function two other curvilinear regression models were used to ascertain whether the relationship between S and I was curvilinear. These were $S = aI^b$ (Cobb - Douglass) $S = a \pm b_1 I \pm b_2 I^2$ (Quadratic)where a, b_1 and b_2 are regression parameters. The Cobb-Douglass model was employed in its linearised form, $\log (S+0.5) = \log (a) + b \log (I+0.5)$. Value of 0.5 was added to each incidence and severity value in order to eliminate the problem of log zero values complicating the analysis. Curvilinear functions were tested for the 2 clones, RRIC 105 which is resistant and GT 1 which is susceptible, in Peenkande which represent a high incidence locality,

Table 1. *Disease incidence (I) and disease severity (S) of 11* Hevea *clones in four locations during October - November 1979*

Clone	Location								Average		L.S.D. (P=0.05)
	Eladuwa		Elston		Hatbawa		Peenkande				
	I	S	I	S	I	S	I	S	I	S	
RRIC 100	11.72	2.47	13.90	1.80	12.92	1.97	10.23	1.61	12.19	1.96	
RRIC 101	12.23	2.45	13.92	2.14	11.40	1.78	13.80	3.08	12.83	2.36	
RRIC 102	14.50	2.94	17.20	2.80	17.42	2.27	13.40	2.73	15.63	2.68	
RRIC 103	10.71	1.79	16.16	2.41	14.12	1.94	12.74	2.15	13.43	2.07	I:2.82
RRIC 104	7.64	1.26	11.65	2.54	8.70	1.10	8.58	1.13	9.14	1.50	
RRIC 105	3.70	0.74	7.01	0.73	7.26	1.25	5.72	0.73	5.92	0.86	
RRIC 107	9.75	1.76	14.47	2.45	14.64	1.69	7.44	1.26	11.57	1.79	
RRIC 118	6.02	1.31	10.64	1.56	7.74	1.61	7.63	1.16	8.00	1.41	S:0.68
RRIM 600	8.64	1.93	11.83	1.74	6.16	1.02	8.17	1.69	8.70	1.59	
PB 86	14.80	3.15	12.50	1.16	16.60	2.18	15.32	2.63	14.80	2.28	
GT 1	10.18	3.27	17.23	2.56	21.69	3.01	19.25	2.89	17.08	2.93	
Average	9.99	2.09	13.31	1.99	12.60	1.80	11.11	1.91			
L. S. D. (P=0.05)	I: 1.70- S: 0.41										

RESULTS

Influence of environment on disease incidence and severity

Disease incidence and severity of different clones for the season October-November, 1979 are given in Table 1. Analysis of these results showed that there was no interaction between the clones and the locations both in respect of I and S. Generally I and S were very high in all the locations for this season.

Results obtained for the I and S during May - June, 1980 are presented in Table 2. An interaction between the clones and the locations was shown only for disease incidence. The results indicate that some clones *viz.* RRIC 105 and RRIC 118 are consistently resistant while some clones *viz.* PB 86, GT 1 and RRIC 101 consistently susceptible in all the locations. The degree of infection in this season was generally low in all the locations.

Table 2. *Disease incidence (I) and disease severity (S) indices of* 11 Hevea *clones in four locations during May - June, 1980*

Clone	Location							
	Eladuwa		Elston		Hatbawa		Peenkande	
	I	S	I	S	I	S	I	S
RRIC 100	4.32	0.45	1.17	0.39	2.90	0.44	4.42	0.58
RRIC 101	5.32	0.65	2.52	0.46	4.80	0.73	7.31	1.15
RRIC 102	3.00	0.34	3.50	0.38	4.20	0.42	5.34	0.81
RRIC 103	3.74	0.55	2.29	0.71	3.42	0.71	6.00	1.21
RRIC 104	3.60	0.41	1.68	0.17	3.21	0.48	6.54	0.54
RRIC 105	2.03	0.21	1.64	0.17	2.84	0.36	4.10	0.44
RRIC 107	4.20	0.28	2.20	0.31	4.43	0.47	4.38	0.71
RRIC 118	2.17	0.22	1.84	0.25	3.00	0.53	3.21	0.29
RRIM 600	2.13	0.28	2.04	0.38	2.20	0.37	5.31	0.79
PB 86	4.41	0.66	3.93	0.93	5.26	0.87	11.20	1.87
GT 1	6.54	0.91	8.89	1.12	4.97	0.82	13.12	2.09

L. S. D. (P=0.05) I= 3.06; S= 0.40

In contrast to the previous two seasons, during the season November-December, 1980 it is seen from the results (Table 3) that in the locality, Peenkande plants were heavily infected while in Elston and Hatbawa they were less infected. Analysis of these results showed that there was an interaction between the clones and locations in respect of both incidence and severity. Similar to the season May-June, 1980, the clones RRIC 105, RRIC 118 and RRIM 600 showed low degree of incidence while the clones RRIC 101, PB 86 and GT 1 showed relatively high degree of I and S in different locations.

Table 3. *Disease incidence (I) and disease severity (S) indices of* 11 Hevea *clones in four locations during November - December,* 1980

Clone	Location							
	Eladuwa		Elston		Hatbawa		Peenkande	
	I	S	I	S	I	S	I	S
RRIC 100	9.35	1.06	3.32	0.32	2.38	0.36	8.66	1.07
RRIC 101	10.46	1.21	5.32	0.18	3.95	0.48	19.82	1.93
RRIC 102	8.78	0.98	5.35	0.63	3.90	0.23	13.97	1.93
RRIC 103	7.15	0.78	5.09	0.65	3.73	0.39	12.58	2.05
RRIC 104	5.71	0.49	2.22	0.24	1.86	0.23	8.74	1.23
RRIC 105	3.28	0.35	1.76	0.18	1.85	0.18	6.67	0.67
RRIC 107	6.25	0.73	3.35	0.39	2.49	0.32	9.66	1.79
RRIC 118	3.55	0.37	1.86	0.23	1.03	0.14	8.65	1.01
RRIM 600	3.72	0.39	1.80	0.18	1.47	0.16	8.94	1.71
PB 86	11.73	2.38	7.04	1.22	7.32	0.68	13.31	3.62
GT 1	19.34	3.94	6.33	1.05	8.05	0.75	26.26	7.09

L. S. D. (P= 0.05) I= 4.40; S= 1.37

The Spearman's Rank Correlation coefficient calculated for incidence and severity with respect to the two locations and two seasons are given in Table 4. On comparison of the locations generally high correlations (0.8091 and 0.9455) were observed for both incidence and severity in high incidence location against low incidence location where the correlations for incidence and severity were 0.8364 and 0.6182 respectively. Similarly, irrespective of the locations high correlations were observed for both incidence and severity during the high incidence season (0.8903 and .8364) compared to values obtained for low incidence season (0.7273 and 0.5543). Generally with the exception of high incidence location, Peenkande, the correlations appeared for incidence (0.7273, 0.8903 and 0.8364) were higher than the corresponding values for severity (0.5543, 0.8364 and 0.6182).

Table 4. *Spearman's Rank Correlations for disease incidence (I) and disease severity (S) of* Hevea *clones with respect to two locations in two seasons*

Location (correspondence between seasons)	Season (correspondence between locations)	Disease Index	Spearman's Rank Correlation
Hatbawa LI		I	0.8364 *
		S	0.6182 *
Peenkande HI		I	0.8091 *
		S	0.9455 *
	May - June 1980 LI	I	0.7273 *
		S	0.5543NS
	November-December 1980 HI	I	0.8903 *
		S	0.8364 *

HI - High incidence; LI - Low incidence
*-Significant at 5% level (9 d. f.)
NS-Not significant.

Relationship between incidence and severity

The relationship between I and S of the disease was explained by the linear regression model $S = a + bI$ and the results are shown in Table 5. Irrespective of locations and seasons high correlations were observed for resistant clones, RRIC 105 and RRIC 118. Similarly in high incidence location, Peenkande a high correlation was recorded in low incidence season, May - June, 1980 than in high incidence season, November - December, 1980. However, in the low incidence location, Hatbawa correlation coefficient did not differ very much with respect to the seasons, May-June, 1980 and November - December, 1980. Comparatively higher values of severity/incidence (S/I), which are denoted by the regression parameter b, were observed for susceptible clones than for resistant clones. Similarly this ratio is higher in high incidence season, November - December, 1980 than in low incidence season, May - June, 1980.

Table 5. *Linear relationship ($S=a+bI$) between disease incidence (I) and disease severity (S) of* C.gloeosporioides *in two locations during two seasons*

Location	Season	Clone	Regression parameter		Standard deviation	Coefficient of determination
			a	b	S_b	(R^2)
		RRIC 105 (R)	-0.0319	0.1325	0.0052	0.9740
	LI	RRIC 118 (R)	-0.1054	0.1644	0.0112	0.9268
	May - June	RRIC 101 (S)	0.0370	0.1591	0.0231	0.7362
	1980	GT 1 (S)	-0.1281	0.1777	0.0148	0.8947
Hatbawa	HI	RRIC 105 (R)	0.0	0.1000	0.0	1.0000
	November-	RRIC 118 (R)	0.0	0.1000	0.0	1.0000
	December	RRIC 101 (S)	0.0077	0.1203	0.0136	0.8219
	1980	GT 1 (S)	0.3449	0.0507	0.0070	0.7541
		RRIC 105 (R)	-0.0648	0.1260	0.0066	0.9551
	LI	RRIC 118 (R)	0.0216	0.0868	0.0043	0.9604
	May - June	RRIC 101 (S)	-0.2803	0.1998	0.0285	0.7430
	1980	GT 1 (S)	-0.3125	0.1826	0.0616	0.8361
Peenkande						
	HI	RRIC 105 (R)	0.0	0.1000	0.0	1.0000
	November-	RRIC 118 (R)	0.0624	0.1098	0.0100	0.8470
	December	RRIC 101 (S)	-0.1836	0.3558	0.0566	0.6966
	1980	GT 1 (S)	-2.9222	0.3963	0.0490	0.7578

HI - High incidence ; LI - Low incidence

Comparison between functions

The relationship between I and S with respect to two curvilinear models are shown in Tables 6 and 7. When the coefficients of determination shown in these two functions for the 2 clones were compared with that obtained for the linear model (Table 5) no significant differences were observed between the degrees of fitness of these models. However, relatively high goodness of fit 0.8225 and 0.8793 were obtained for the two curvilinear models *viz.* Quadratic and Cobb-Douglass for susceptible clones in high incidence season compared to those obtained with linear model (0.7578).

Table 6. *Curvilinear (Quadratic $S=a+b_1I+b_2I^2$) relationship between disease incidence (I) and disease severity (S) of resistant (R) and susceptible (S) clones to* C. gloeosporioides *in a high incidence location (Peenkande) in two seasons*

Season	Clone	Regression parameter			Standard deviation		Coefficient of determination
		a	b_1	b_2	Sb_1	Sb_2	(R^2)
LI	RRIC 105 (R)	0.0386	0.0628	0.0058	0.0145	0.0013	0.9805
May-June 1980	GT 1 (S)	0.0476	0.1455	0.0009	0.0799	0.0019	0.8363
HI	RRIC 105 (R)	0.0	0.1000	0.0	0.0546	0.0012	1.0000
November - December 1980	GT 1 (S)	0.2509	0.0501	0.0059	0.1500	0.0007	0.8225

HI — High incidence; LI — Low incidence

Table 7. *Curvilinear (Cobb-Doughless, $S=aI^b$) relationship between disease incidence (I) and disease severity (S) of resistant (R) and susceptible (S) clones to* C. gloeosporioides *in a high incidence location (Peenkande) in two seasons*

Season	Clone	Regression parameter		Standard deviation		Coefficient of determination
		a	b	S_a	Sb	(R^2)
LI	RRIC 105 (R)	-0.6857	0.4446	0.0574	0.0392	0.8830
May - June 1980	GT 1 (S)	-1.3334	0.8660	0.2435	0.0967	0.8250
HI	RRIC 105 (R)	-0.5947	0.4061	0.0561	0.0294	0.9185
November - December 1980	GT 1 (S)	-1.7465	1.1032	0.3032	0.0990	0.8793

HI - High incidence ; LI - Low incidence

DISCUSSION

Hevea clones showing differential susceptibility to *C. gloeosporioides* have been reported earlier (Liyanage, 1976). Our study confirmed those observations. The relative differences in overall incidence and severity in different locations could have been due to the variation in climatic factors. The results showed that generally highly resistant and highly susceptible clones are not markedly affected by environmental differences. But the interactions shown between the clones which show intermediate degree of resistance differ in different locations. Thus the breakdown of resistance of certain hosts can take place under the influence of different environmental conditions.

Spearman's Rank Correlation provides a useful measure of the correspondence between the clones in respect of disease resistance or susceptibility. It is evident that a high incidence season as well as high incidence location accompanys a high potentiality, to discriminate between clones for their inherent susceptibility to the disease. Similarly when the two indices, I and S are considered individually, relatively higher correlations for I as compared to S indicate that the index, I helps to discriminate between clones better than the index, severity under the observed levels.

In this study, other than the functions $S=aI^b$ two models $S=a+bI$ and $S=a_1I+b_2I^2$ are similar to those used by Reddy, Rao and Prasad (1979) in bacterial leaf blight of rice. By establishing the relationship between I and S if one of the factors is known the other factor can be estimated. Thus a considerable saving in time and labour can be achieved.

It appears from the results that the linear model could be fitted to all the environmental conditions with sufficiently high coefficient of determination. However there are limitations in the application of this model as the relationship may hold only within the observed range of incidence and severity levels. As shown in the results an increase in incidence and severity levels is accompanied by low goodness of fit values. High goodness of fit values obtained for resistant clones as well as for the clones in a low incidence season even in high incidence location suggest that this linear model can be applied better when the plants are less affected. Thus the linear relationship shown in all the conditions could have been due to the low degree of incidence that was prevailant during the survey.

As described by James and Shih (1973) if the incidence and severity of the disease were very high one should expect the relationship to behave exponentially. When the three functions, linear and two curvilinear were compared similar trend was evident; the relationship for a susceptible clone in high incidence season being curvilinear.

Disease incidence is an error free measurement as it determines only the presence or absence of the disease (James and Shih, 1973; James, 1974). However, estimation based only on a single factor *i.e.* incidence or severity does not seem to be satisfactory for a meaningful evaluation of their resistance under field conditions since both incidence and severity are complimentary indices. Therefore estimates based on both parameters could offer a better estimate of the field resistance of the clones; such a combined index is provided by the ratio of severity to incidence and given by the regression value, b. Susceptible clones are characterized by higher values for S/I. Similarly results indicate that S/I values are higher in high incidence seasons as well as in high incidence locations.

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