

# A MODEL FOR PREDICTING THE 'BLACK POD' DEVELOPMENT IN CACAO UNDER LABORATORY CONDITIONS

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## ABSTRACT

Five cacao varieties were screened for 'black pod' development by *Phytophthora* in semi-mature; harvested pods. The size of lesions on pods of each variety was measured on 5 consecutive days. The results showed that the rate of lesion development could be fitted to an exponential curve. This curve may be useful for predicting the lesion size within a 5 day period.

## INTRODUCTION

The 'black pod' is an important disease of cacao (*Theobroma cacao* L.) in all the cacao growing areas of the world. This disease has been attributed to several species of *Phytophthora* such as *P. megakarya* (Brasier & Griffin, 1979), *P. capsici* (Kaosiri, 1978), *P. citrophthora* (Kellam & Zentmyer, 1981), *P. botryosa* (Chee, 1969a), *P. heveae* (Chee, 1969), *P. drechsleri* (Tucker, 1931), *P. meadii* (Sreenivasan, 1975), *P. katsurae* (Liyanaige & Wheeler, 1989). *P. palmivora*, however, is the most widespread in the tropic and considered to be the most important among all species causing 'black pod' in cacao. In Sri Lanka, the causal organism of this disease is *P. palmivora* morphological form 1 (Liyanaige & Threemanne, 1982; Bandara *et al.*, 1985; Seneviratne, 1987).

Kularatne & Jacob (1980) have screened 11 cultivars of cacao grown locally for *P. palmivora* -pod infection and showed a significant varietal difference in disease development among the cultivars. There is no other information available concerning 'black pod' disease development or its forecast in Sri Lanka. This paper describes some experiments conducted to obtain data to develop a system for predicting the 'black pod' development under local conditions.

## MATERIALS AND METHODS

Five cacao varieties namely W5/5, W5/398, W6/434, ICS and SCA 6 x ICS6 obtained from the Minor Export Crops (Export Agriculture) Research Station in Matale (Sri Lanka) and its sub-station at Kundasale were screened for *Phytophthora* infection in the pod.

The pods were harvested at the semi-mature stage about a month prior to their usual harvesting age. They were brought to the laboratory and undamaged healthy pods were selected and used in the experiments.

### Pond inoculation

The pods were wiped with a piece of cotton wool soaked with 70% ethyl alcohol and allowed to dry. Six pods of each variety were inoculated with mycelial plugs from a 3 day old *Phytophthora palmivora* (isolate No. Kn 13) culture grown on 2.3% Difco Lima Bean Agar (LBA) at  $28 \pm 1^\circ\text{C}$  in the dark.

A disc of tissue was removed from each pod with a 4mm sterile cork borer and replaced with a mycelial plug taken from the periphery of the colony by inserting it just below the surface. Another 6 pods from each variety were similarly inoculated with an agar disc without the mycelium as the control. Pods kept in moist chambers covered with black polythene at room temperature ( $28 \pm 2^\circ\text{C}$ ).

The margins of the lesions were traced onto a tracing paper after 2,3,4,5 and 6 days of inoculation and the area covered by the lesions was measured by a planimeter.

## RESULTS

Mean sizes of lesions produced on pods of five cacao cultivars by *P. palmivora* at different time intervals after inoculation are given in the Table 1.

Table 1. Mean lesion size on cocoa pods of 5 varieties, measured on 5 consecutive days

Variety	<sup>a</sup> Mean lesion size (cm <sup>2</sup> )				
	2nd day	3rd day	4th day	5th day	6th day
W5/5	6.19	27.10	67.48	156.97	347.35
W5/398	6.84	22.77	58.97	144.26	403.61
W6/434	7.48	30.97	75.03	155.16	334.84
ICS I	2.52	17.23	47.23	127.61	319.35
SCA6 x ICS6	5.29	18.58	42.19	85.68	223.23
Overall mean	5.57	23.51	58.18	133.94	325.68

a = each value is an average of 6 readings

Lesion development in the five varieties examined showed a significant ( $P < 0.001$ ) variety x day interaction (Table 2).

Table 2. Lesion development on different cocoa varieties during 5 days after inoculation with *Phytophthora* isolate No. Kn13

ANOVA				
Source	df	SS	MS	F
Variety	4	54472.02	13617.38	8.3***
Error 1	25	41224.25	1648.97	
Day	4(1)	2043980.60	508924.42	560.85***
Variety x Day	16(4)	74696.64	4668.44	5.15**
Error	100(25)	90742.30	907.42	

Conservative degrees of freedom are given within brackets

However, compared to the main effect of "Day", this interaction is very small. Therefore, upon plotting the average lesion growth for each day, for each variety, one exponential curve (non-linear) could be fitted generally to all 5 varieties within the range of the 5 days. The values for the equation fitted are shown in Table 3.

**Table 3. Values of the Exponential equation fitted.**

Variety Exponential equation fitted $Y = Ae^{BX}$			
	A	B	R <sup>2</sup>
W5/5	0.4758	0.9777	0.98
W5/398	0.4294	1.0002	0.99
W6/434	0.6041	0.9213	0.98
ICS.1	0.1784	1.1690	0.97
SCA6 x ICS 6	0.3944	0.9013	0.99
Overall five Varieties	0.4108	0.9843	0.99

Where Y = Average lesion growth

X = Day

R<sup>2</sup> = Coefficient of determination

A & B = Constants

The Exponential curves fitted for the varieties SCA 6 x ICS 6, ICS 1, W6/434, W5/398, W5/5 and for the 5 varieties overall are shown in Figs.1,2,3,4,5 and 6 respectively.

The exponential curves fitted showed that lesion growth increases at an increasing rate upto 5 days irrespective of the variety studied. The R<sup>2</sup> values for all 5 varieties were in the range of 0.97-0.99. The fitted values and the actual values more or less coincided for the varieties SCA 6 x ICS 6 and W5/398, their R<sup>2</sup> value being 0.99, whereas for the other three varieties the fitted values tend to separate at the 5th day, their R<sup>2</sup> value being between 0.97 and 0.98.

## DISCUSSION

There is general agreement that the susceptibility to disease of detached pods is greater than that of attached pods (Medeiros and Rocha, 1964; Rocha and Mariano, 1969; Blaha, 1967; Tarjot, 1967a). However, a degree of resistance of detached pods under laboratory conditions could be used as an indication of the far higher resistance to be expected from the pod on the trees (Lellis and Peixoto, 1960). One difficulty in using pods on the trees for screening is in the interpretation of the results when a number of variable environmental factors, which cannot be adequately controlled, are involved.

In general, the percentage success of experimental infection indicated by the number of lesions and the spread of the infected spot on the entire pod, are the criteria used for the classification of cocoa varieties as resistance or susceptible. Tarjot (1967b; 1969) developed a "Susceptibility Index" which took into account simultaneously the percentage of successful infection and the time taken for the appearance of the spot (spread of lesion). Blaha (1971, 1971a) used, as a criterion, the average spread of the disease by noting the increase in size of the spot in mm<sup>2</sup> per 24 hours.

In the varieties SCA6 x ICS6 and W5/398, the fitted values and the actual values almost coincided upto 5 days. The fitted values and the overall value for 5 varieties were almost identical upto 4 days and on the 5th day the actual value and the fitted value tend to separate from each other showing that the fitted curve did not work well for these varieties beyond the 4th day. These results suggest that the change in lesion size with time is well suited for a sigmoid curve. However, the fitted exponential curve may be useful for predicting within the range of a 5 day period, and this equation may not be valid for predicting values beyond the 5th day. Therefore it is advisable to try some non-linear types of the form  $Y = A/(1 + BP^X)$ ,  $0 < P < 1$  (Where A and B are constant for the purpose of predicting beyond the 5th day).

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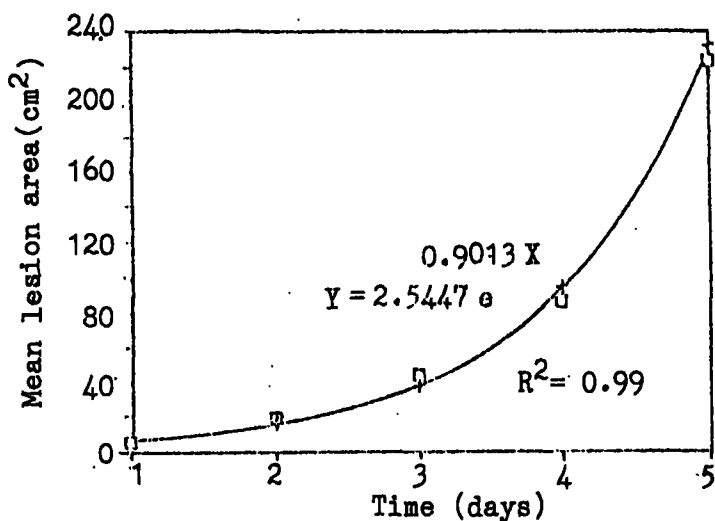


Figure 1. Mean lesion area (cm<sup>2</sup>) on cocoa pods of SCA 6 x ICS 6, for 5 days

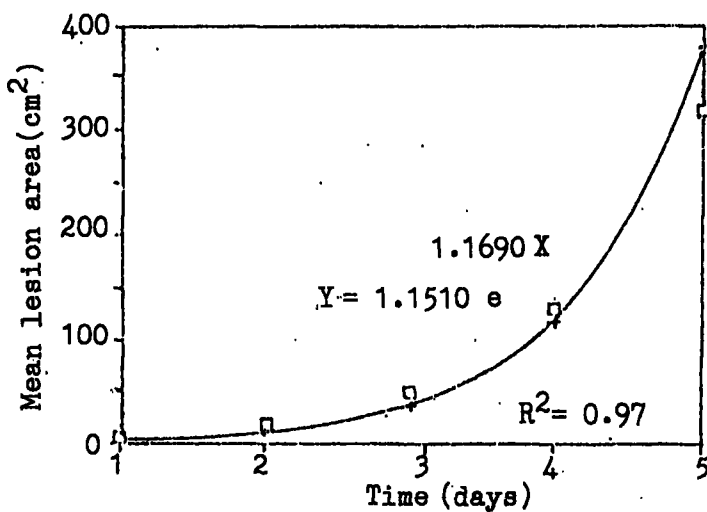


Figure 2. Mean lesion area (cm<sup>2</sup>) on cocoa pods of variety ICS 1 for 5 days

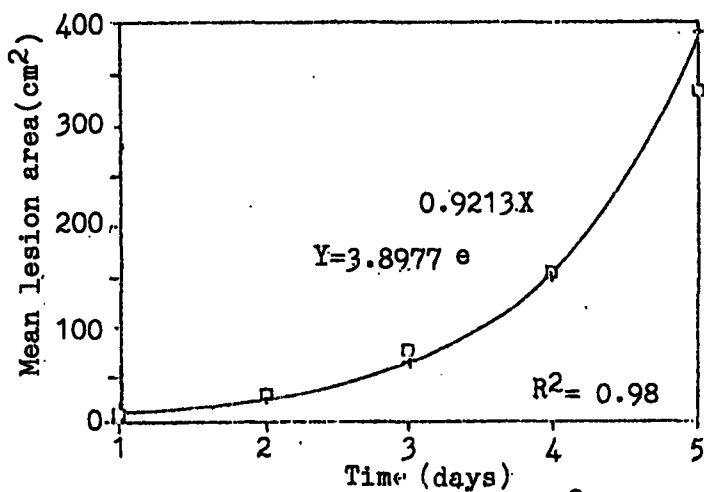


Figure 3. Mean lesion area (cm<sup>2</sup>) on cocoa pods of variety W6/434 for 5 days

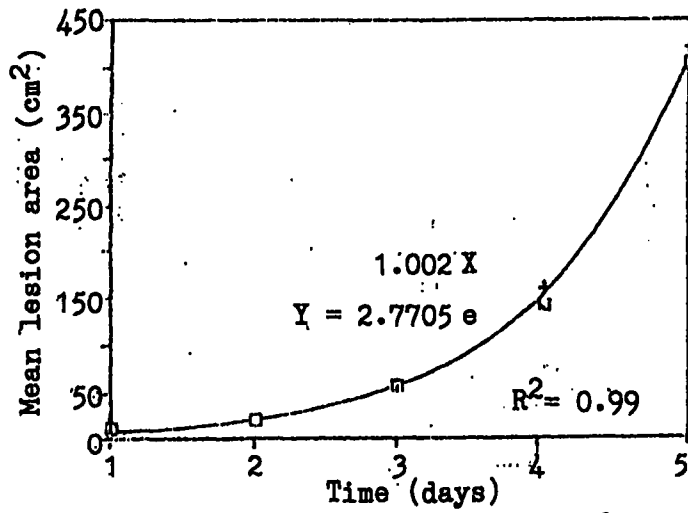


Figure 4. Mean lesion area (cm<sup>2</sup>) cocoa pods of variety W5/398 for 5 days

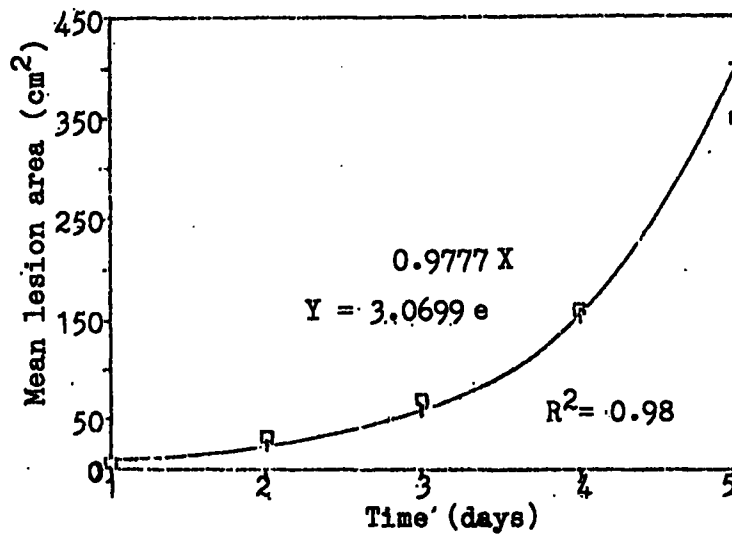


Figure 5. Mean lesion area (cm<sup>2</sup>) on cocoa pods of variety W5/5 for 5 days

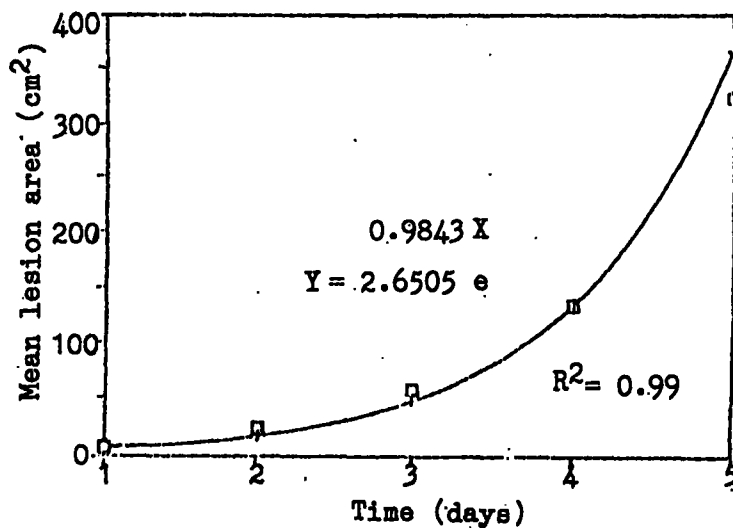


Figure 6. Mean lesion area (cm<sup>2</sup>) on cocoa pods of all 5 varieties (SCA 6 x ICS 6, ICS 1, W6/434, W5/398, W5/5) for 5 days

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