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Clonal Nursery Studies in Hevea II. Relationship between Yield and Girth

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The relationship between yield and girth of nursery plants of trees within the same clone has been examined at two stages for eighty clones and found to conform to a linear expression. From 23 to 98% of the variation in yield has been accounted for by the regression of yield on girth.

Selection of higher yields in the nursery takes into account higher regression constants as well. The two constants of the linear expression are related to some of the clonal characters.

Nursery selection criteria which relate to yield as well as vigour offer opportunities for increased discrimination in the early screening of Hevea progenies. The relationship of yield and girth of mature trees within clones has been adequately expressed (NARAYANAN AND HO, 1970) in linear form as

$$y' = -c + dx \qquad \ldots (1)$$

or in curvilinear form as

$$y = ax^b \qquad \ldots (2)$$

i.e. $\log y = \log a + b \log x$

The present study determines whether linear regression is equally applicable to nursery material, with a view to investigating it as an indication of clonal variation in the efficiency of latex production.

EXPERIMENTAL

Records of yield and girth of individual trees of between eleven and eighteen trees of each of eighty clones were taken from a nursery trial in the Experiment Station (HO *et al.*, 1973). The total yields were recorded during two periods — March 1967 (six tappings) and February 1969 (four tappings), corresponding girths being measured at a height of 102 centimetres.

The initial processing of the data and the statistical techniques employed have already been described (NARAYANAN AND HO, 1970).

RESULTS AND DISCUSSION

The details of the regression equations have not been given individually for all the clones, but frequency distributions of the constants in the linear and curvilinear equations have been made for each of the two periods (*Figure 1*). The regression coefficients in the linear case vary between 0.2 and 2.6 for the first period and between 0.6 and 2.8 for the second. The regression coefficients in the curvilinear case, on the other hand, vary between 0.8 and 8.8 in the first period and between 1.4 and 3.6 in the second. The distribution of the regression coefficients is nearly symmetrical. The relationships of the yield-girth regression coefficients between the two periods are closer in the linear ($r = 0.677$) than in the curvilinear ($r = 0.314$) representation.

Figure 2 shows the percentage cumulative frequency distributions of the correlation coefficients obtained by the two forms of expression for both periods under study. With the exception of AVROS 1502 in the first period, significant correlations between

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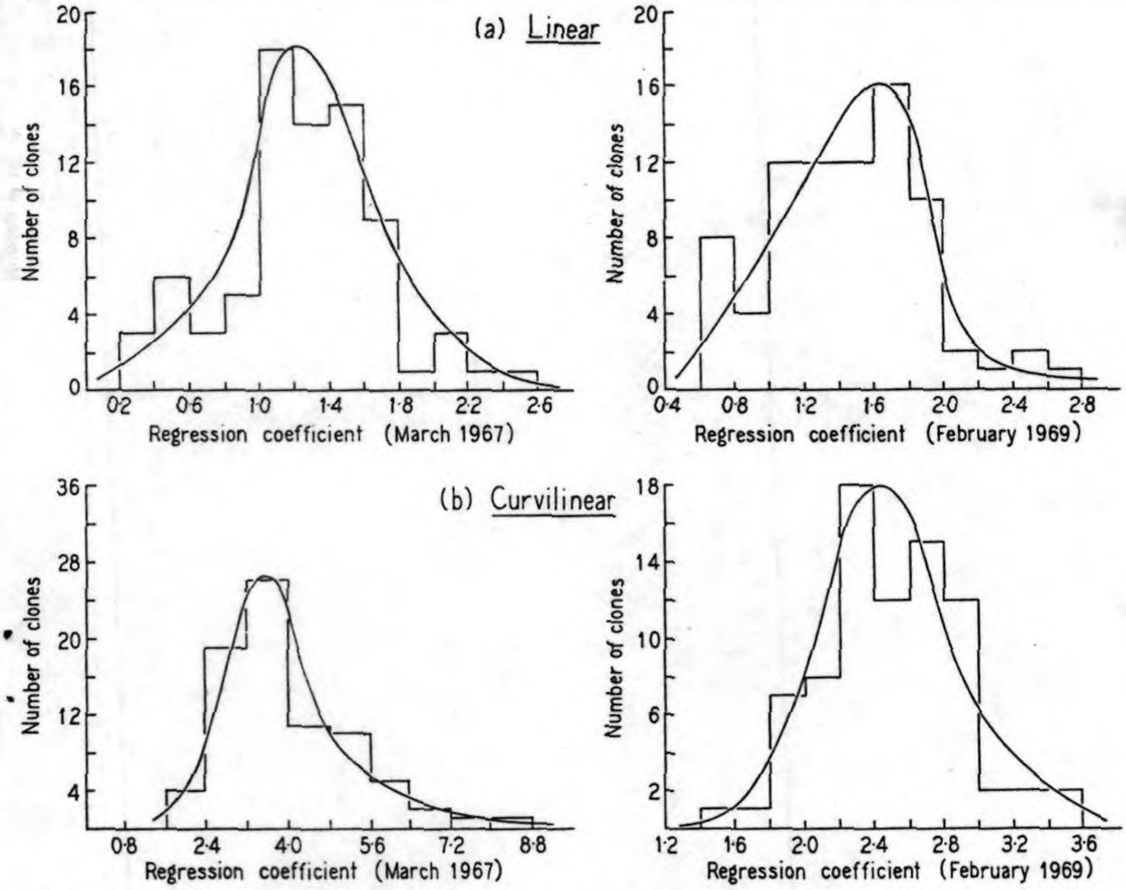

Figure 1. Frequency histograms of the regression coefficients in the linear and curvilinear relationships between yield and girth.

yield and girth were obtained with both equations in both periods. The correlation coefficients exceed 0.80 in 77 and 68% of the clones for linear and curvilinear expressions respectively for the first period and in about 95% of the clones in the second period. The correlation coefficients vary between 0.48 and 0.97 for the first period and between 0.64 and 0.99 for the second, indicating that 23 to 98% of the variation between the individual tree yield records has been accounted for by the linear or by the curvilinear relationships.

Table 1 shows the frequency distributions of the percentage departures (NARAYANAN AND HO, 1970) which vary between 10 and 80%. *Figures 3a* and *b* compare the percentage departures between the linear and curvilinear expressions for the two periods. In order to determine if the percentage departures are similar in both cases, an expression of the form $y = mx$ is fitted to the data; m is significantly different from unity in both periods. The percentage departures are slightly smaller for the linear compared to the curvilinear expression in the first period, whilst in the second period the departures are slightly smaller for the curvilinear than the linear expression. The better curvilinear fit at fifty-six months can be

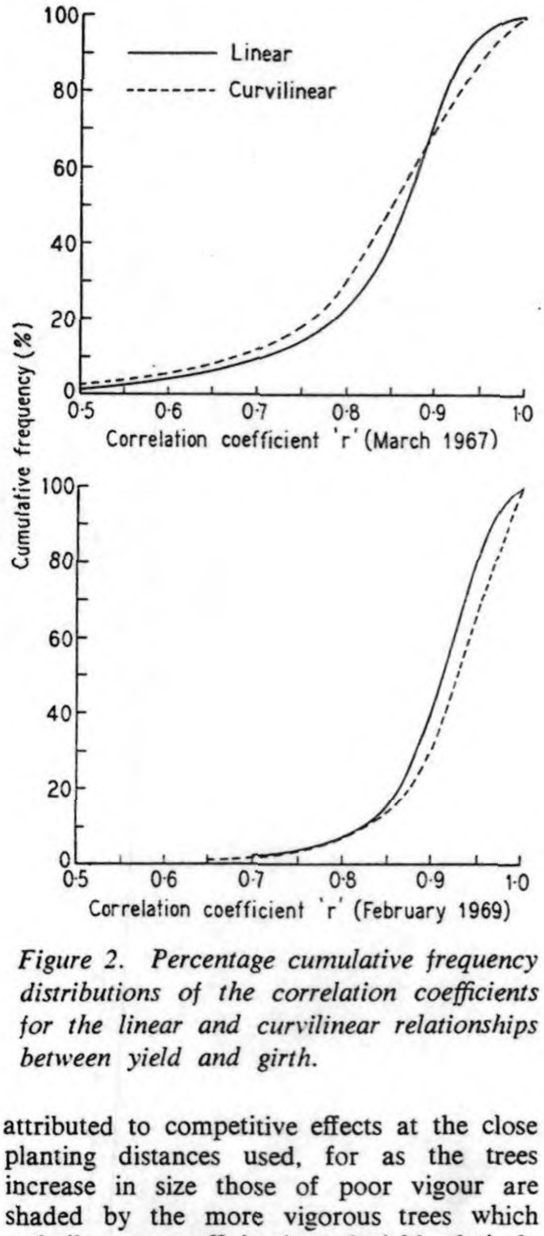

Figure 2. Percentage cumulative frequency distributions of the correlation coefficients for the linear and curvilinear relationships between yield and girth.

attributed to competitive effects at the close planting distances used, for as the trees increase in size those of poor vigour are shaded by the more vigorous trees which assimilate more efficiently and yield relatively more than their girth would appear to indicate. (This was borne out by the higher proportion of the linear and curvilinear forms occurring within the least and most vigorous groups of clones respectively in the first period. In the second period, by considering only the clones with the poorest and the

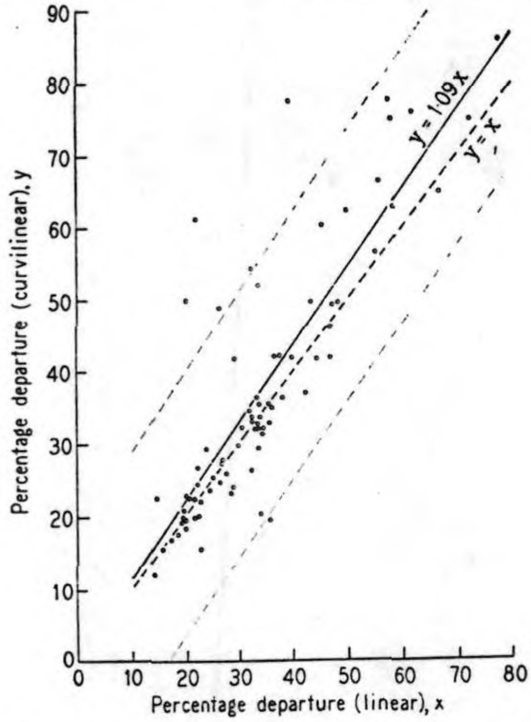

Figure 3a. Variation of percentage departures between the linear and curvilinear relationships of yield and girth (March 1967).

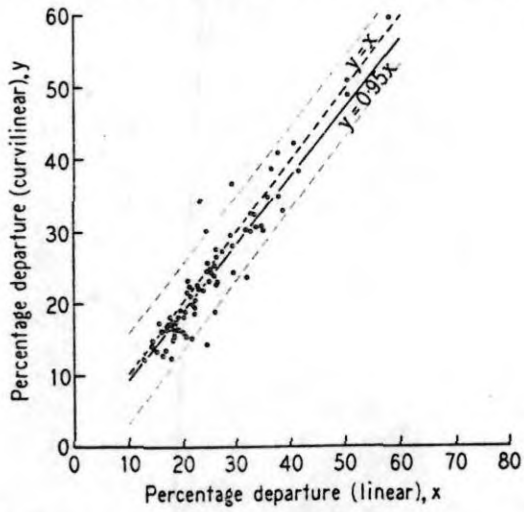

Figure 3b. Variation of percentage departures between the linear and curvilinear relationships of yield and girth (February 1969).

TABLE 1. FREQUENCY DISTRIBUTIONS OF THE PERCENTAGE DEPARTURES FOR LINEAR AND CURVILINEAR RELATIONSHIPS BETWEEN YIELD AND GIRTH

Class interval	March 1967		Class interval	February 1969	
	Linear	Curvilinear		Linear	Curvilinear
10 – 20	9	11	10 – 15	4	9
20 – 30	25	24	15 – 20	19	24
30 – 40	25	17	20 – 25	22	19
40 – 50	10	11	25 – 30	17	9
50 – 60	6	5	30 – 35	7	10
60 – 70	2	5	35 – 40	6	4
70 – 80	2	5	40 – 45	2	2
80 – 90	0	1	45 – 50	–	1
			50 – 55	2	1
			55 –60	1	1
Total	79[a]	79[a]	Total	80	80

[a] Excluding AVROS 1502

best girthing rates within these two groups, a similar pattern emerged.)

Figures 4a and *b* illustrate the linear and curvilinear regressions and their 95% confidence limits for four representative clones. The girth ranges vary between 7 and 19 cm for the first period and from 11 to 35 cm for the second period. The linear expression fits the observed data better than the curvilinear expression for higher girth ranges while the reverse is true for lower girth ranges (see also NARAYANAN AND HO, 1970). Over the entire girth ranges both expressions fit the data equally well, and hence the linear expression is preferred because of its simplicity.

It is clear from the variations in the regression coefficients and intercepts that the linear relationship between yield and girth differs markedly between clones. The distributions of the linear regression coefficients (*Figure 1a*) show that fifteen clones in the first period and thirty two clones in the second period have a regression coefficient of 1.6 or more. *Figures 5a* and *b* plot the linear regression constants against mean yield; the correlation coefficient is highly significant in both cases, indicating a close association between the two variates.

Twenty clones with the highest yields and twenty with the highest regression constants were selected from the percentage cumulative distributions for the two periods and are listed in *Table 2*. Fourteen clones are common to both periods on the basis of yield, and eleven on the basis of the regression constants. Comparing the regression constants in the first period with the yields from both periods, thirteen and ten clones respectively are common to both periods. When the regression constants in the second period are compared with the yields, twelve clones are common to both periods. Thus the selection of higher yields in the nursery automatically takes into

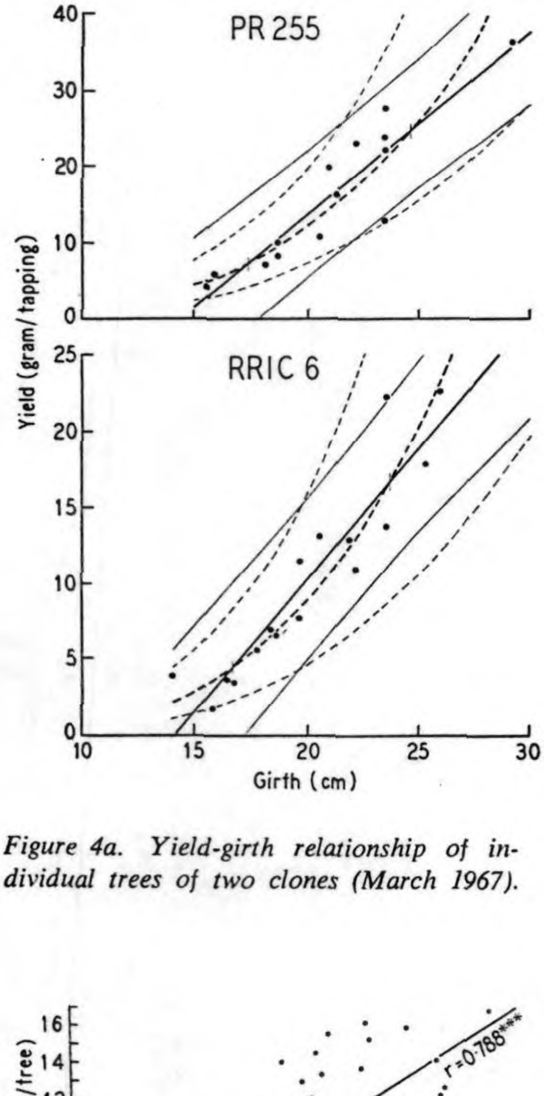

Figure 4a. Yield-girth relationship of individual trees of two clones (March 1967).

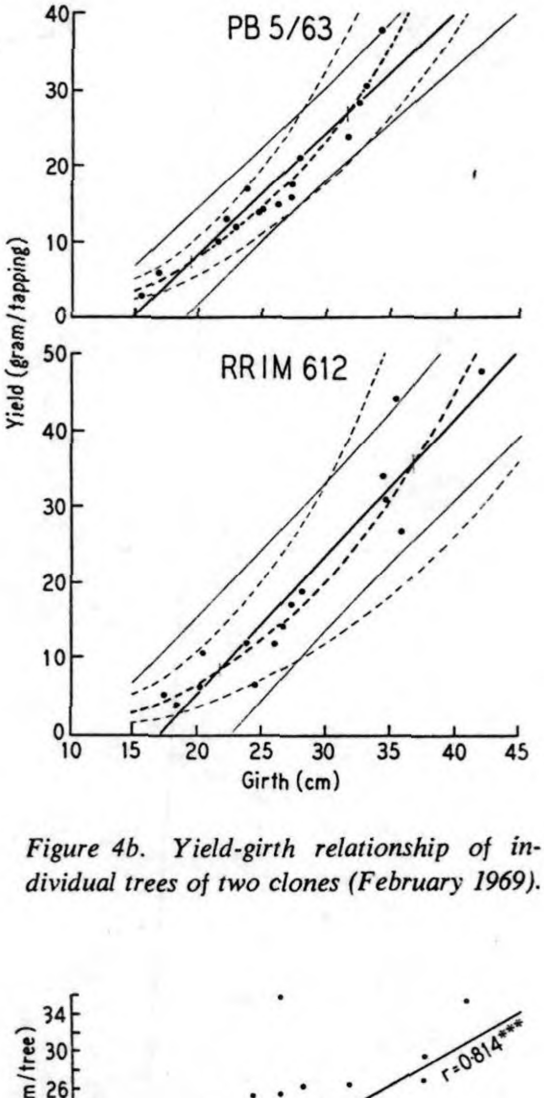

Figure 4b. Yield-girth relationship of individual trees of two clones (February 1969).

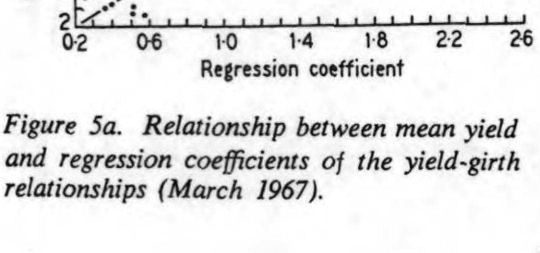

Figure 5a. Relationship between mean yield and regression coefficients of the yield-girth relationships (March 1967).

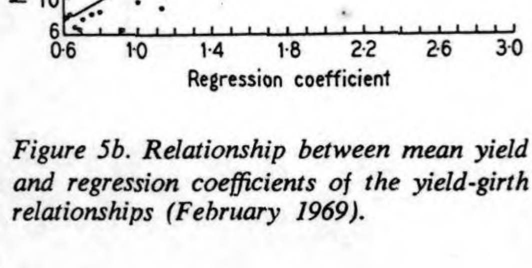

Figure 5b. Relationship between mean yield and regression coefficients of the yield-girth relationships (February 1969).

TABLE 2. TWENTY CLONES WITH THE HIGHEST YIELDS AND YIELD-GIRTH REGRESSION COEFFICIENTS AMONG THE EIGHTY CLONES STUDIED

No.	Regression constant				Yield			
	March 1967		February 1969		March 1967		February 1969	
1	AVROS	427	AVROS	427	AVROS	1279	AVROS	1279
2	AVROS	1279	AVROS	1191	AVROS	1350	AVROS	1350
3	AVROS	1518	AVROS	1279	AVROS	1518	AVROS	1518
4	AVROS	1734	AVROS	1735	PB	5/51	AVROS	2037
5	AVROS	1735	IRIC	9	PR	231	GT	1
6	GT	1	PR	251	PR	251	IRCI	9
7	PR	231	PR	255	PR	255	PB	5/51
8	PR	249	PR	259	PR	259	PB	28/59
9	PR	255	RRIC	5	RRIC	7	PR	251
10	PR	259	RRIC	6	RRIC	14	PR	255
11	PR	261	RRIC	7	RRIC	41	PR	259
12	RRIC	6	RRIC	14	RRIM	600	RRIC	5
13	RRIC	7	RRIM	600	RRIM	605	RRIC	6
14	RRIC	14	RRIM	605	RRIM	614	RRIC	14
15	RRIM	600	RRIM	612	RRIM	623	RRIM	600
16	RRIM	614	RRIM	614	RRIM	632	RRIM	605
17	RRIM	623	RRIM	615	RRIM	636	RRIM	632
18	RRIM	632	RRIM	623	RRIM	701	RRIM	636
19	RRIM	636	RRIM	707	RRIM	707	RRIM	707
20	RRIM	701	TR	3702	TR	3702	TR	3702

account the higher regression constants (rate of increase in yield per unit increase in girth). Since the slopes and intercepts of the relationship between girth and yield are related, it follows that the higher-yielding clones also have higher intercepts.

The variation in the regression constants and the intercepts in the linear relationships for the eighty clones reflect clonal characteristics. The relationships of these two constants with the clonal characteristics, total number of latex vessel rings, bark thickness and average distance between consecutive latex vessel rings are significant; those with the diameter of the latex vessels or sieve-tubes and with the density are not significant *(Table 3)*.

CONCLUSIONS

The relationship between yield and girth within clones at the nursery stage can be expressed more satisfactorily in linear than in curvilinear terms. The correlation coefficient (r) varies between 0.48 and 0.99,

TABLE 3. LINEAR CORRELATIONS OF THE TWO CONSTANTS OF THE YIELD-GIRTH RELATIONSHIP WITH CLONAL CHARACTERISTICS DATA OF MARCH 1967

Character	Correlation with	
	Regression coefficient *(d)*	Intercept *(c)*
Total number of LV rings	0.477***	0.357***
Bark thickness (mm)	0.347**	0.442***
Distance between consecutive LV rings (mm)	0.272*	0.332**
Density of LV per 5mm of ring	−0.167	−0.156
Diameter of LV (μ)	−0.037	−0.013
Diameter of sieve tubes (μ)	0.073	0.001

*** $P < 0.001$ ** $P < 0.01$ * $P < 0.05$

thus accounting for about 23 to 98% of the variation in yield of individual trees.

Selection for higher yields at the nursery stage will favour clones with higher regression coefficients, *i.e.* clones with higher rates of increase in yield for unit increase in girth. The constants of the linear expression are correlated with the total number of latex vessel rings, bark thickness and distance between consecutive latex vessel rings, but not with the density or diameter of either latex vessels or sieve-tubes.

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Nursery Screening of Hevea for Resistance to Gloeosporium Leaf Disease

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A nursery method of assessing clonal susceptibility to natural infection by Gloeosporium leaf disease (caused by Colletotrichum gloeosporioides) *is described. Results from nine screening nurseries are presented, and nearly 200 clones classified according to their degree of susceptibility. A satisfactory agreement was found to exist between nursery assessment and field susceptibility to the disease, although the latter is modified for some clones by their wintering pattern.*

Gloeosporium leaf disease (GLD), caused by *Colletotrichum gloeosporioides* Penz., is widespread throughout Malaysia and results in defoliation of young leaf during wet weather. It is particularly severe in inland districts of Perak, Selangor and Johore (WASTIE, 1972), and in these areas it is a major cause of the post-wintering defoliation known as secondary leaf fall.

Clones differ widely in their susceptibility to GLD; from observations on 120 foreign exchange clones, PAARDEKOOPER (1964) showed that the repeated defoliation suffered by clones of above average susceptibility to GLD appreciably retarded growth during the maturity. HO *et al.* (1969) reported that the more GLD-susceptible clones performed better in Negri Sembilan and Malacca, where the disease is less severe than elsewhere. Better performance of susceptibile material can also be achieved by crown-budding with a resistant clone (YOON, 1967). In view of the difficulty of chemically controlling the disease, it has been accepted that the most practicable way of combatting it is to plant resistant clones (WASTIE, 1969), employing the most suitable clones for each planting district as indicated by HO *et al.* (1969). A preliminary list of clonal susceptibilities was published by WASTIE (1967), but it included only thirty clones and is based largely on information obtained from exchange-clone trials by PAARDEKOOPER (1964 and 1965). The present work was undertaken to develop a reproducible method of assessing clonal susceptibilities to GLD. This paper describes a nursery screening method whose results correlate with field experience, and reports the results obtained in 1965 – 72 with the first 194 clones tested.

METHODS

Nursery Design

In order to test the validity of screening clones at an early stage of their growth in a nursery — *i.e.* within the first year of budding — thirty clones whose susceptibility to GLD had already been ascertained from field observations (PAARDEKOOPER, 1965) were selected. These clones, ranging in reaction to the disease from highly susceptible to highly resistant, were budded in a nursery in Johore, where prolonged exposure to GLD could be ensured. Germinated seeds were planted 0.6 m square in a continuous block of 3000 plants, and plots of twenty plants, distributed in a randomised block design with five replications, were green-budded with each test clone. Subsequent nurseries followed a similar design, although the number of

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