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AN ANALYSIS OF GROWTH PATTERNS OF HEVEA CLONES

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ABSTRACT

Four girth measurements collected over four years, before tapping, from ten Hevea Clones grown in two sites have been analysed to study the growth pattern.

Year to year variation in both sites was mainly due to linear component of growth. Growth of individual clones too was mainly due to linear effect. But some clones in one site showed significant quadratic and or cubic component. This was due to non linear growth of plants in some plots.

Ten clones have been grouped (a) according to the girth when averaged over four years so that clones within a group have the same average girth and (b) on the gradient of the regression fitted to the girth measurement increasing over the four years.

RRIC 52 had the fastest growth in both sites. RRIC 103 had the same growth rates in both sites suggesting that it has a greater stability to local environmental changes.

INTRODUCTION

One of the important economic characters to be considered in the breeding and selection of *Hevea* clones is vigour in terms of girth increase. Vigorous clones reach tappable girth early thus reducing the uneconomical immature period. The objectives of this study are (1) To apply statistical techniques to study, in detail, the growth patterns of Hevea clones grown in two different agro-climatic areas. (2) Using the results of the analysis to group or rank clones according to their growth characteristics and identify promising clones.

MATERIALS AND METHODS

Data analysed were collected from two experimental sites, which constituted a part of a large experiment, originally planted in nine locations to study the genotype-enviroment interactions in Hevea.

Experimental material consisted of ten clones, both local and foreign. In both places 10 fully randomized plots were planed. At Moralioya site which is in a wet area plot size was 4 while at Bibile site where the weather conditions are fairly dry 6 plants per plot were planted.

In the statistical analysis plot means were used. When computing plot means for Moralioya all the surviving plants were used. Due to death or damaged trees actual degree of freedom of error item is less than the expected degrees of freedom. In Bibile where plot size was 6, in computing plot means 4 plants were selected at random out of the surviving plants. Since there were sufficient surviving plants the actual degrees of freedom for error item was 499 which is the expected number.

Girth, considered as a measure of growth, analysed in this paper was recorded annualy at 90 cm from the highest point of bud union. Four girth measurements recorded from 1978 to 1981, prior to opening of tapping cuts, were used for analysis. Two experimental sites, are located on Densworth Estate (earlier a part of Moralioya Estate) in the wet zone and on Bibile Estate in the dry zone.

RESULTS AND DISCUSSION

In order to study the variability of girth measurements over years and clones and the interaction between these two factors, analyses of variance were done using plot means. Since the data are the girth measurements of the same set of trees over 4 years, the year differences which were expected, is mainly due to growth of the trees. This variation with 3 degrees of freedom was partitioned into 3 components, linear quadratic and cubic, each with one degree of freedom and results are presented in Table 1, separately for the two sites, Densworth and Bibile. It is evident that most of the year to year variation was due to the linear effects of growth. Clone differences were also evident as shown by the highly significant F-ratios. However, the year by clone interaction was significant only for trees grown in the Densworth site. This suggests that clones responded differentially to year variation in Densworth, but when grown in Bibile, response of these clones, to year variation was similar to each other as indicated by non-significant year by clone interaction.

Table 1 indicates that when the whose site was considered the year variation was mainly due to the linear component of growth. Since there are significant differrnces between clones there may be different patterns of growth of clones which was not evident in the above analyses. To examine the pattern of growth of individual clones the average girth measurement of each clone was analysed seperately. The results summarised in Table 2 confirmed the very strong linear effect in the year to year variation, but certain clones in Bibile showed slight quadratic and/or cubic effects. For example, RRIC 52 in Bibile had both quadratic and cubic effects significant at 1% level.

Table 1. *Analysis of variance of plot means and partitioning of year differences into linear quadratic and cubic components.*

Densworth site					
Source of variation		d.f.	S. S.	M. S.	F. Ratio
Linear component		1	56325.000	56325.000	4662.660**
Quadratic	„	1	00004.602	00004.602	0000.382**
Cubic	„	1	00006.141	00006.141	0000.508
Clones	„	9	05098.000	00566.500	0271.053**
Year X Clone		27	00686.300	00025.420	0002.104**
Error		356	04302.700	00012.080	

Table 1. *(Contd.) Analysis of variance of plot means and partitioning of year differeances into linear quadratic and cubic components.*

Bibile site

Source of variation		d.f.	S. S.	M. S.	F. Ratio
Linear component		1	32460.000	32460.000	2017.400**
Quadratic	„	1	00030.390	00030.390	0001.798**
Cubic	„	1	00054.810	00054.810	0003.243
Clones	„	9	03835.000	00426.100	0025.378
Year X Clone		27	00494.400	00018.310	0001.090
Error		360	06046.000	00016.790	

** Significant at 1% level

Table 2. *F-values of the analysis of variance on individual clones to seperate linear, quadratic and cubic components.*

Densworth site

Clones		Linear	Quadratic	Cubic
PB	86	3161.59*	0.567	0.044
RRIC	100	2659.42*	0.694	0.385
RRIC	101	3483.60*	1.987	0.284
RRIC	103	5281.90*	0.391	0.514
RRIC	52	2515.98*	0.178	2.044
RRIM	600	1705.10*	2.141	0.047
RRIC	36	1996.00*	0.227	0.481
RRIM	623	2476.99*	0.108	0.558
RRIC	102	5224.69*	2.139	0.233
IAN	45/710	3167.32*	0.001	0.054

Bibile site

Clones		Linear	Quadratic	Cubic
PB	86	1597.00*	1.846	1.945
RRIC	100	6431.97*	9.862*	0.570
RRIC	101	1367.45*	0.449	8.765*
RRIC	103	1424.78*	0.027	0.869
RRIC	52	2114.48*	8.533*	6.625*
RRIM	600	1000.00*	0.242	1.136
RRIC	36	1507.17*	0.287	2.341
RRIM	623	1038.90*	0.065	1.258
RRIC	102	810.87*	2.040	0.537
IAN	45/710	1942.14*	7.429*	05.811*

* Significant at 1% level

Since all the clones in Densworth and most of the clones in Bibile had linear growth, clones which showed quadratic and cubic components were further studied to determine whether differences in growth between plots is the cause for significant non-linear growth. The plot means plotted against the year of measurement for RRIC 101 and RRIC 52 are presented in Fig. 1 & Fig. 2. It is clear that in the case of RRIC 101 growth in plot numbers 4, 5 and 6 was non-linear while in the case of RRIC 52 plot numbers 5, 6, 8 and 9 showed non-linear growth. In other clones too the cause for non linearity was due to differences in grtowth between different plots.

Same analysis of varaiance on individual clones which showed significant quadratic and/or cubic effects, were repeated after removing the data of plots which showed non-linear effects. F values of this re-analysis on RRIC 101 and RRIC 52 are presented in Table 3. It indicates that once the suspected non-linear plots are removed the quadratic and cubic components turned out to be non-significant confirming the earlier observation.

Table 3. *F-values of the reanalysis on RRIC 101 and RRIC 52*

Clones	Plots removed	F-ratio		
		Linear	Quadratic	Cubic
RRIC 100	4, 5, 6	2720.390**	1.756	0.700
RRIC 52	5, 6, 8, 9,	4940.270**	1.373	1.081

** Significant at 1%

It is clear that the non-linear growth of some clones are due to odd behaviour of plants grown in some plots. This odd behaviour could be due to some soil condition in those plots which could have affected the growth of the plants grown in those plots.

Grouping of clones

First the grouping was done so that the clones within a group have the same mean girth when averaged over 4 years. Groups for the two sites are given in Table 4 a. To check wehether there are differences between clones within groups, an analysis of variance was done on the data of each group. This showed that there were no differences between clones within any group at Densworth site. But Group 1 and Group 3 of Bibile showed significant differences between clones within groups as indicated in the results presented in Table 5.

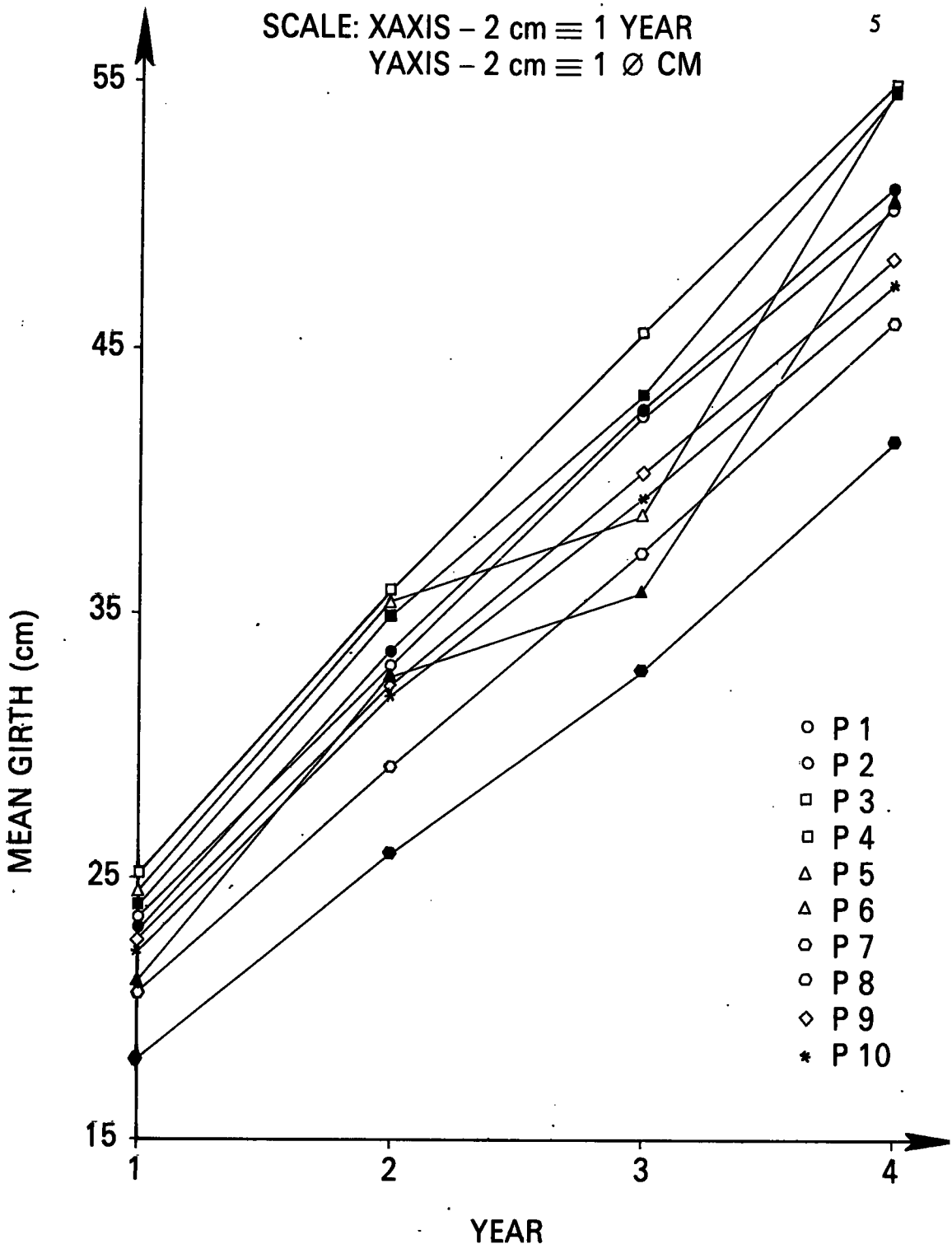

Fig. 1. Average girth (in cm) of RRIC 101 for each plot against the year of measurement.

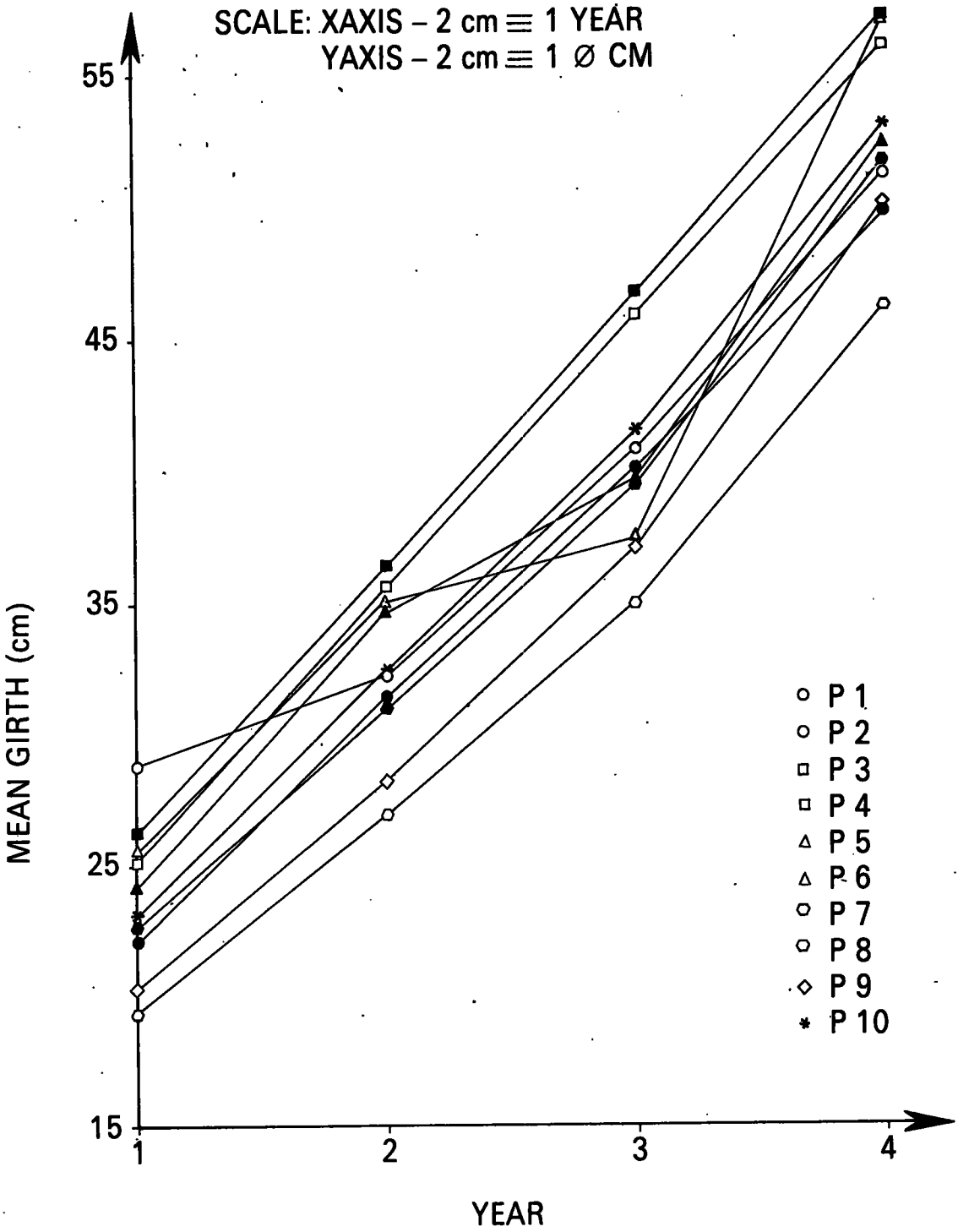

Fig. 2. Average girth (in cm) of RRIC 52 for each plot against year of measurement.

Table 4 a. *Grouping of clones according to their means*

Group	1	2	3	4	5
	RRIC 101	RRIC 52	RRIC 103	IAN 45/710	RRIC 100
Deansworth	RRIC 102		RRIM 623		PB 86 RRIM 600 RRIC 36
Bibile	RRIC 103 RRIC 52 RRIC 36	RRIM 600 RRIM 623	PB 86 RRIC 100 RRIC 101 IAN 45/710 RRIC 102		

Table 4 b *Regrouping of clones in Bibile site*

1	2	3	4	5	6	7
RRIC 36	RRIC 103 RRIC 52	RRIM 600 RRIM 623	RRIC 101 IAN 45/710	RRIC 100	PB 86	RRIC 102

Table 5. *Results of the analyses of variance on Groups 1 and Group 3 data of Bibile site.*

Group 1 Clones RRIC 103, RRIC 52 and RRIC 36

Source of variation	S.S.	d. f.	M.S.	F
Years	1382.619	3	460.873	2351.390*
Clones	2.565	2	1.282	6.541*
Residual	1.175	6	0.196	

Group 3 Clones PB 86, RRIC 101, RRIC 102 and IAN 45/710

Source of variation	S.S.	d. f.	M.S.	F
Years	1408.079	3	469.360	345.117*
Clones	51.008	4	2.752	9.376*
Residual	16.319	12	1.360	

* Significant at 1% level.

Possibility of regrouping clones in these two groups of Bibile site was explored by using least significant differences which in the case of Group 1 is 0.224 indicating that RRIC 36 was different from the other two clones, RRIC 103 and RRIC 52. For the Group 3 least significant differnces is 0.737 indicating that RRIC 101 and IAN 45/710 were similar to each other while RRIC 100, PB 86, and RRIC 102 were not. On this basis clones grown in Bibile could be rearranged into 7 groups as given in Table 4 b. A further grouping based on the gradient (considered as the rate of growth) of the regression fitted to the girth measurement increasing over the four years was performed. The model $Y = a + bx$ was fitted where a is the intercept, b is the gradient, x (4 years) is the independent variable and is the dependent variable which has 40 girth measurements that is, ten plot means in each of the 4 years. In Table 6 clones are ranked according to the rate of growth estimated as gradients of the regression lines. It is clear from these results that RRIC 52 had the fastest growth rate in both experimental sites followed by RRIC 101 at Densworth. It occupied the third position in Bibile. In comparison with other clones RRIC 103 had a good growth rate in Bibile in relation to other clones but had lower ranking position in Densworth although in absolute performance there was little difference in growth rates of RRIC 103 over the two sites. This shows that RRIC 103 has a greater stability in being least affected by local effects.

Table 6. *clones ranked according to their gradients of regression lines.*

	Densworth Site		Bibile Site	
Rank	(Gradients in decreasing order)	Clone	(Gradients in decreasing order)	Clone
1	12.67	RRIC 52	9.59	RRIC 52
2	12.63	RRIC 101	9.04	RRIC 103
3	11.25	RRIC 102	9.03	RRIC 101
4	10.61	RRIM 100	8.70	RRIC 100
5	10.43	RRIM 623	7.94	RRIC 36.
6	10.04	RRIC 36	7.93	RRIC 102
7	9.83	IAN 45/710	7.68	IAN 45/710
8	9.62	RRIC 103	7.34	RRIM 623
9	9.53	RRIM 600	6.83	RRIM 600
10	9.00	PB 86	6.51	PB 86

CONCLUSIONS

Rubber being a perennial crop, repeated measurements from the same tree over several years are possible. As in the case of girth such repeated measurement could be analysed to study the growth pattern of different clones. Further these information could be used to group the clones. Such a techniques will be useful to the Hevea breeder in assessing selected genotypes for vigour and arranging them into groups with similar growth patterns. The results showed that RRIC clones are more suitable for the sites considered, than the other clones included in this study.

The highest mean girth at the tappable stage was attained by RRIC 101 in Densworth site. This could be explained by its high growth rate. RRIC 36 had the highest mean girth in Bibile site, although it didn't have a very high growth rate when compared with the others.

The rate of growth and mean girth in Densworth site were quite higher than that of Bibile which may partly be explained by the weather.

This study is restricted to the study of growth pattern during the 4 years just before opening of the tapping cuts. It will be interesting to do a similar study on the girth measurements recorded after the commencement of taping to check whether growth pattern and relative growth rates change as a response to tapping which is a stress factor.

REFERENCES

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