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A STUDY OF GROWTH PARAMETERS IN A POPULATION OF NURSERY ROOTSTOCK SEEDLINGS OF *HEVEA BRASILIENSIS*, CV. TJIR 1

PART ONE

By

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ABSTRACT

Growth measurements of a few characters were made on a population of seedlings of Hevea brasiliensis, cv. *Tjir 1 in a rootstocks nursery. Preliminary data are presented on the rate of germination, height and diameter of seedlings and the leaf area. Comparisons of the different growth parameters suggest that early germinators continued to maintain their superior vigour over the late germinators even five months after transplanting. The study also reveals that the diameter of rootstock seedlings can be used as a convenient parameter to separate vigorous and non-vigorous rootstock seedlings for future studies on the budded plants grown in the field.*

INTRODUCTION

Cultivars of *Hevea brasiliensis* are multiplied for use in estate plantings by budgrafting them to proven rootstocks. Unselected illegitimate seedlings of *cv.* Tjir 1 have been used in Ceylon until now. This method of vegetative propagation ensures that the tapping panels of a replanted monoclonal stand are isogenic. Genetic uniformity however has not reduced the variability of growth and yield of such stands to a level that the plantation industry would desire. The coefficient of variation of growth and yield of seedling populations of early plantings has been reported by Whitby (1919), Sharp (1940) and Hardon (1969) to range from 50—65%. In spite of the use of budgrafts the coefficient of variation is still high though lesser than for seedlings. A reduction of the existing range of variation still further would increase the average plantation yields with the use of existing cultivars.

The growth and yield of the same cultivar on different rootstock families have been known to vary (O'Brien, 1945; De Silva, 1947). Recognition of favourable stock-scion combinations therefore allows us to increase potential yields; but the tree to tree variation still exists within families. Soil heterogeneity has been suggested as a possible cause for the observed variation in growth and yield of trees in monoclonal stands (De Silva, 1954; McIndoe, 1958; Senanayake & Wijewantha, 1968). Inherent variability in the growth and vigour of the rootstock seedlings has also been suggested as another possible cause (McIndoe, 1958; Senanayake & Wijewantha, 1968). Reducing the influence of the rootstock variation through rootstock selection may allow us to obtain more uniform yields from the trees of monoclonal stands.

Recognising that vegetative propagules like rooted cuttings would eliminate the problem of genetic heterogeneity of illegitimate seedling rootstocks, Baptiste (1939) and McIndoe (1958) developed techniques for rooting. Their use in estate plantings however has not been successful, probably because the shallow plageotropic root system was susceptible to wind damage.

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Reports on the influence of the rootstock on the performance of the scions of *Hevea brasiliensis* cultivars are conflicting. Few reports suggest that vigorous rootstocks give better scion growth and yield (Ostendorf, 1944; Sharp, 1939). Others suggest that the influence of the rootstock is unimportant (O'Brien, 1944). There is confirmatory evidence however that the latex yield of the rootstock influences the yield of the scion when the tapping cut approaches the bud union (O'Brien, 1942; Baptiste, 1962).

The objectives of the current investigation are, firstly, to study the nature of variation of growth of unselected illegitimate seedlings in a rootstock nursery so as to determine an easy parameter of growth for rootstock selection, and secondly to study the nature of growth and yield of budlings on rootstocks that exhibit differences in vigour in the nursery. The nature of early growth of seedlings is examined in this paper.

MATERIALS AND METHODS

About 2,000 open pollinated Tjir 1 seeds from Palmgarden Group (Kuruwita) were sown on a germination bed on 19 August 1969. The bed was irrigated twice a day.

Germination counts were taken every other day, beginning 31 August 1969. Germinated seeds were randomized and transplanted in four beds on 10, 11, 12, 13, 14, 15 and 16 September 1969 according to recommended procedures (Peries, 1955).

Plants were fertilized on 15 October 1969 with animal meal at the rate of one oz per plant. Two applications of copper fungicidal sprays were carried on 30 October 1969 and 18 November 1969.

The first measurement of plant height was taken on 15 October and measurements were recorded at monthly intervals thereafter. The height was recorded from ground level to the stem apex. The first measurement of plant girth was taken on 14 November 1969 and measurements were taken at monthly intervals thereafter. The girth of the stem was measured at 7·5 cm above the ground. Leaf area measurements were taken using the method of Thirumalachary (1940). The first recording was taken on 1 December 1969 and subsequent ones at the beginning of each month. A random sample of 300 plants was chosen to measure the leaf area.

RESULTS AND DISCUSSION

Rates of growth

The frequency distribution of the germination period shows that the range of germination was 22 days and germination was completed in about 34 days after sowing (Fig. 1). The distribution of the germination curve is positively skewed suggesting that the rate of germination is quicker during the early stages and it slows down during the later stages.

The mean growth in height (Table 1 and Fig. 2) shows that late germinators had grown less and this condition was evident even after five months. It seems therefore that the early germinators are inherently more vigorous and their ability to germinate sooner was probably not due to differences in the reserve food in the seed or the micro-environmental conditions in the germination bed. Stem diameter in relation to the germination period (Table 2 and Fig. 3) also shows that late germinators have smaller stem diameters than the early germinators, even after five months.

TABLE 1

MEAN GROWTH OF HEIGHT

Period of germination (days)	Number germinated	Mean height (cm) $\bar{x} \pm$ t. SE				
		Stage 1 15. 10. 69	Stage 2 14. 11. 69	Stage 3 15. 12. 69	Stage 4 15. 1. 70	Stage 5 15. 2. 70
12	10	30·6±4·1	38·0±5·8	45·9±7·0	53·4±8·7	62·7±10·3
14	24	30·8±2·2	39·3±2·7	47·5±3·6	55·2±3·9	49·5± 5·1
16	54	29·3±1·6	37·8±1·8	46·0±2·5	52·6±3·1	64·7± 4·2
18	267	31·1±0·8	38·8±0·9	46·5±1·1	53·5±1·3	64·9± 1·7
20	324	31·8±0·8	38·6±0·9	46·0±1·1	52·5±1·3	63·5± 1·6
22	185	31·2±1·1	38·1±1·2	45·3±1·4	51·6±1·7	62·3± 2·2
24	207	26·4±0·9	33·9±1·1	41·5±1·5	48·0±1·7	58·1± 2·3
26	82	24·5±1·5	32·9±1·1	40·2±2·3	46·9±2·9	57·2± 3·6
28	73	20·3±1·7	29·4±2·2	37·6±2·8	43·7±3·2	52·2± 4·3
30	38	17·0±1·5	25·6±2·4	34·0±3·0	39·7±3·7	48·7± 5·2
32	11	15·0±4·4	25·3±5·2	33·7±7·1	40·3±9·6	51·4±13·7
34	16	11·9±2·4	21·3±4·2	27·4±4·7	34·5±6·3	42·0± 8·6

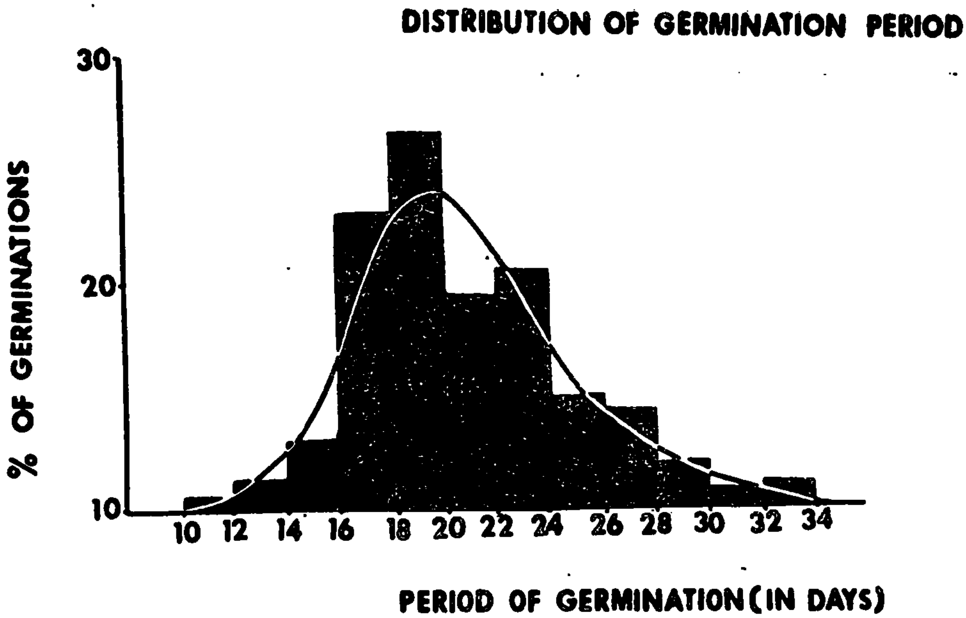

Fig. 1. Frequency distribution of the germination period.

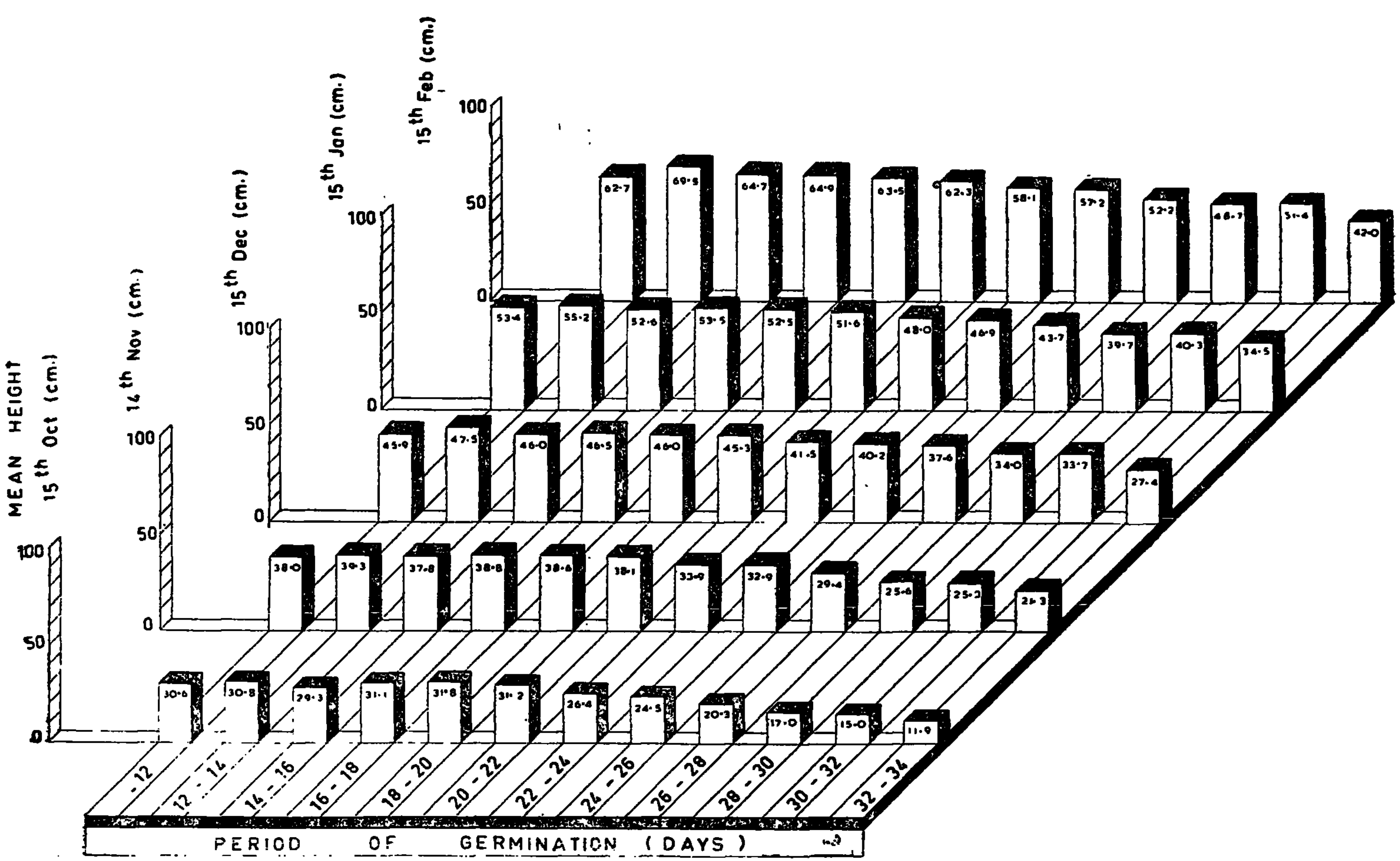

Fig. 2. Monthly growth in height of seedlings which germinated during different periods.

TABLE 2

MEAN STEM DIAMETER OF SEEDLINGS

Period of germination (days)	Number of germinations	Mean stem diameter (cm)			
		Stage 2 14. 11. 69	Stage 3 15. 12. 69	Stage 4 15. 1.70	Stage 5 15. 2. 70
12	10	0·33	0·45	0·60	0·69
14	24	0·38	0·54	0·68	0·80
16	54	0·34	0·50	0·62	0·75
18	267	0·34	0·49	0·63	0·74
20	324	0·33	0·48	0·60	0·71
22	185	0·33	0·47	0·59	0·70
24	207	0·30	0·45	0·56	0·66
26	82	0·30	0·44	0·56	0·66
28	73	0·28	0·42	0·51	0·61
30	38	0·25	0·37	0·47	0·55
32	11	0·27	0·38	0·48	0·58
34	16	0·22	0·30	0·40	0·47

Comparisons were made between germination period and the rate of growth in height and rate of growth in diameter (Tables 3 and 4). The rate of growth is the difference in growth during a monthly interval. During interval I the late germinators had a higher rate of growth in height. During interval II there was no difference between early and late germinators. During interval III and interval IV the late germinators had a lower rate of growth, *i.e.* a significant negative correlation. During interval IV the negative correlation was much stronger.

TABLE 3

GROWTH RATES (HEIGHT)

Period of germination (days)	Number of germinations	Rate of growth of height/month (cm)			
		Interval I 15/10–14/11	Interval II 14/11–15/12	Interval III 15/12–15/1	Interval IV 15/1–15/2
12	10	7·4	7·9	8·5	9·3
14	24	8·5	8·2	7·7	14·3
16	54	8·5	8·2	6·6	12·1
18	267	7·7	7·7	7·0	11·4
20	324	6·8	7·4	6·5	11·0
22	185	6·9	7·2	6·3	10·7
24	207	7·5	7·6	6·5	10·1
26	82	8·4	7·3	6·7	10·3
28	73	9·1	8·2	6·1	8·5
30	38	8·6	8·4	5·7	9·0
32	11	10·3	8·4	6·6	11·1
34	16	10·4	6·1	7·1	7·5

Correlations: Germ. period × rate of growth (ht) in interval I = + 0·4802
" " × " " " " " II = − 0·0641
" " × " " " " " III = − 0·6060
" " × " " " " " IV = − 0·8451

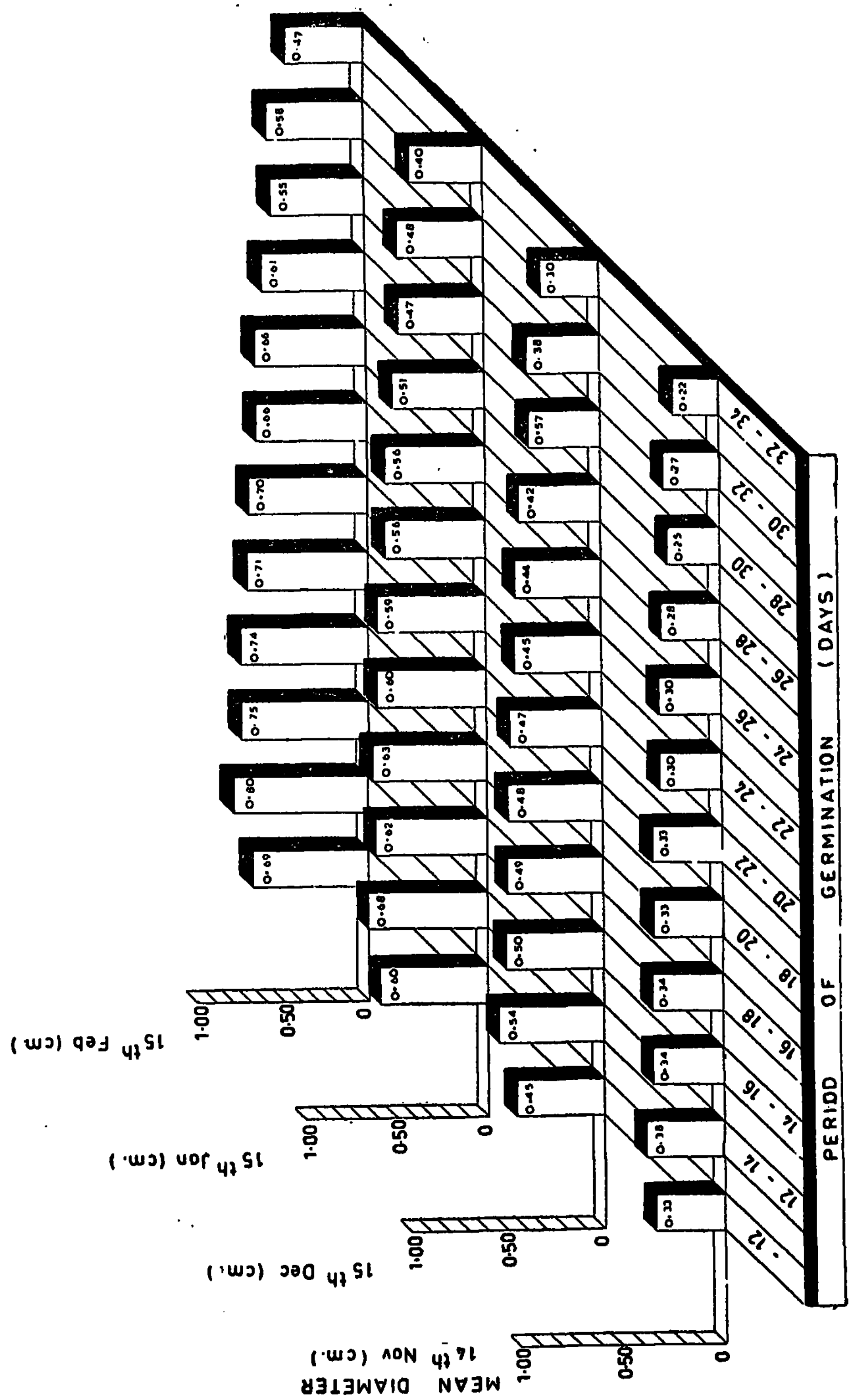

Fig. 3. Monthly growth in diameter of seedlings which germinated during different periods.

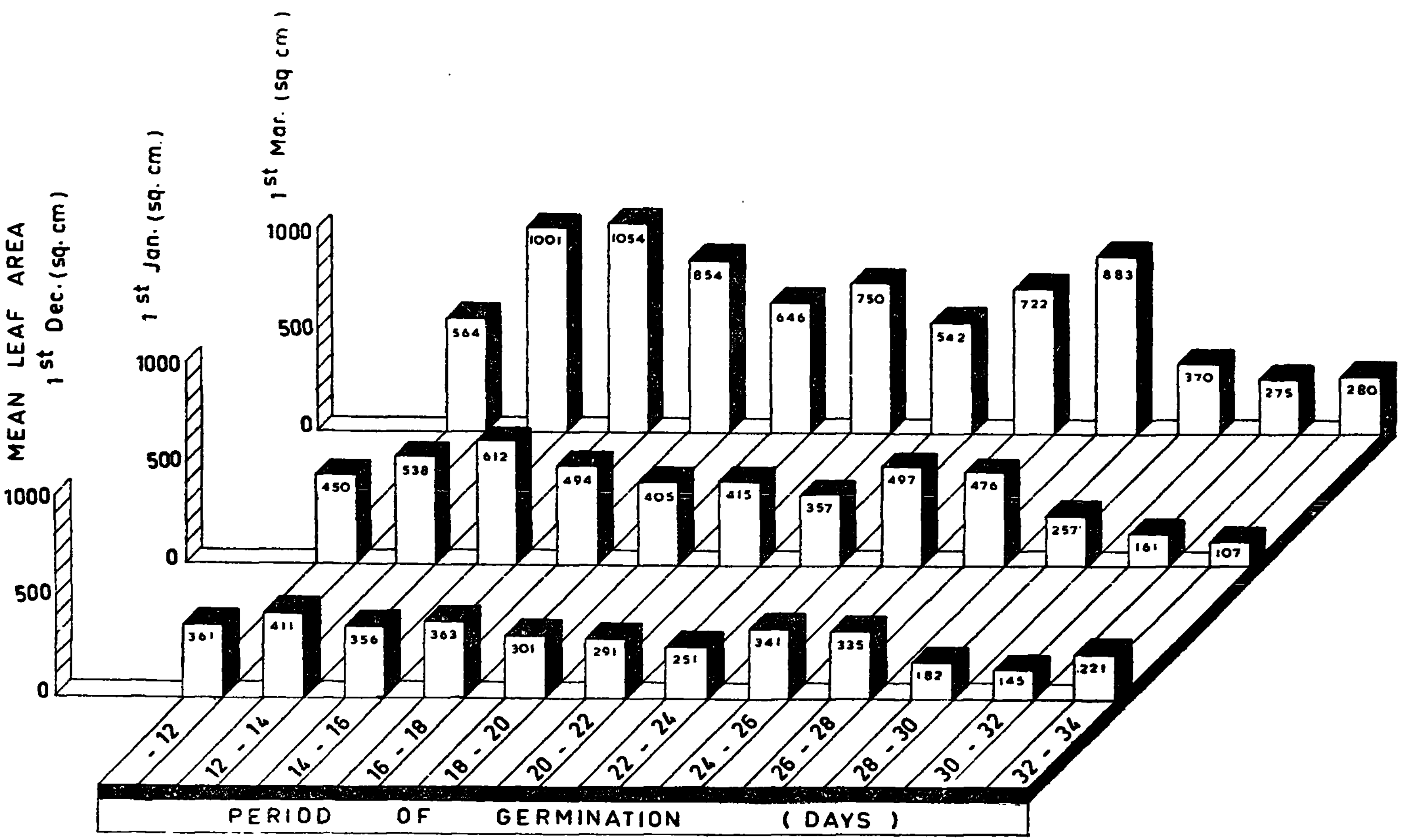

Fig. 4. Leaf area of seedlings which germinated during different periods.

TABLE 4

GROWTH RATES (DIAMETER)

Period of germination (days)	Number of germinations	Rate of growth of stem diameter/month (cm)		
		Interval II 14/11–15/12	Interval III 15/12–15/1	Interval IV 15/1–15/2
12	10	0·12	0·15	0·09
14	24	0·16	0·14	0·12
16	54	0·16	0·12	0·13
18	267	0·15	0·14	0·11
20	324	0·15	0·12	0·11
22	185	0·14	0·12	0·11
24	207	0·15	0·11	0·10
26	82	0·14	0·12	0·10
28	73	0·14	0·09	0·10
30	38	0·12	0·10	0·08
32	11	0·11	0·10	0·10
34	16	0·08	0·10	0·07

Correlations : Germ. period × rate of growth (diameter) during interval II = -0·6927
" " × " " " " " " III = -0·8235
" " × " " " " " " IV = -0·8001

An analysis of the rate of growth of diameter also confirms the negative correlation relationship which was evident during the later intervals of growth in height. Vigour of growth expressed either as the rate of growth in stem height or stem diameter follows a similar trend.

The relationship between germination period and leaf area is presented in Fig. 4 and Table 5. Leaf area measurements also show that late germinators had a lower development of leaf area. The comparison of the rate of growth in leaf area is given in Table 6. The data which has been analysed in this study for the two intervals show that the late germinators have lower rates of growth in leaf area. The degree of relationship is however much lower than in the case of height or diameter. This can be explained by the fact that leaves abscise during short periods of moisture stress and the leaf area that is recorded for the remaining leaves may not be a true estimate of the functional leaf area.

TABLE 5

MEAN LEAF AREA OF SEEDLINGS

Period of germination (days)	Number of germinations	Mean leaf area (sq cm)		
		Stage 3 1st Dec.	Stage 4 1st Jan.	Stage 5 1st March
12	5	360·7	449·8	563·6
14	6	410·6	537·8	1001·4
16	12	356·1	611·8	1053·8
18	57	362·6	494·2	854·3
20	57	300·9	404·7	646·2
22	41	291·4	415·3	749·8
24	35	251·2	357·3	542·4
26	14	340·6	496·8	722·0
28	10	335·1	476·4	883·4
30	10	182·2	256·8	369·9
32	2	144·8	160·8	274·5
34	1	221·0	107·0	279·5

TABLE 6

GROWTH RATES (LEAF AREA)

Period of germination (days)	Number of germinations	Rate of growth of leaf area/month	
		Interval III 1/12–1/1	Interval IV 1/1–1/3
12	5	89·1	113·8
14	6	127·8	463·6
16	12	255·7	442·0
18	57	131·6	360·1
20	57	103·8	241·5
22	41	123·9	334·5
24	35	106·1	185·1
26	14	156·2	225·2
28	10	141·3	407·0
30	10	74·6	113·1
32	2	16·0	113·7
34	1	114·0	172·5

Correlations : Germ. period vs. rate of growth (leaf area) during interval III = −0·4467
" " " " " " " " " " IV = −0·4868

It may be seen therefore from the data presented so far that later germinators generally have lower vegetative vigour as expressed by the measurement of height and diameter and rate of growth of height and rate of growth of diameter. The early data also seem to suggest that the leaf area development is poor in late germinators.

Inter-relationship between growth characters

An examination of inter-relations between the different growth characters such as height and diameter, height and leaf area, and stem diameter and leaf area was carried out in order to identify a common growth parameter that may be used for future selection work (Table 7).

A preliminary study which was confined to a population of 1,000 Tjir 1 seedlings in a rootstock nursery established in 1968 at Nivitigalakele showed that the height and diameter were positively correlated (Fig. 5). We could therefore use stem diameter as a suitable parameter for separating rootstock seedlings into vigorous and non-vigorous classes.

The inter-relationship between leaf area and height presented in Table 7, clearly shows that the plant height is significantly correlated with leaf area. This relationship becomes stronger when the date of measurement of height approaches the date of measurement of leaf area. This suggests that the measurement of leaf area is a good indicator of vigour.

TABLE 7

CORRELATIONS BETWEEN LEAF AREA, HEIGHT AND DIAMETER

	Leaf area		
	Stage 3 1. 12. 69	Stage 4 1. 1. 70	Stage 5 1. 3. 70
Height at stage 1 (15/10)	+0·5725	+0·4946	+0·4415
„ „ stage 2 (14/11)	+0·7117	+0·6286	+0·5485
„ „ stage 3 (15/12)	+0·7686	+0·7320	+0·6561
„ „ stage 4 (1/1)	+0·7880	+0·6966	+0·6875
„ „ stage 5 (1/2)	+0·7826	+0·7553	+0·7796
Diameter at stage 2 (14/11)	+0·6726	+0·5244	+0·4665
„ „ stage 3 (15/12)	+0·7637	+0·6469	+0·5971
„ „ stage 4 (1/1)	+0·8111	+0·7512	+0·6996
„ „ stage 5 (1/2)	+0·8074	+0·7874	+0·7773

Correlations between leaf area and diameter also follow the pattern observed for leaf area and height (Table 7). Stem diameter is significantly correlated with leaf area and here again the relationship becomes stronger when the date of measurement of the diameter approaches the date of measurement of leaf area. Comparisons of leaf area with stem height and stem diameter provide additional evidence to indicate that stem diameter can be selected as a growth parameter which could be measured easily in the nursery. These studies therefore suggest that we can use rootstock stem diameters as a convenient parameter of growth for separating seedlings on the basis of vigour.

Culling efficiency of early measurements

The height of plants in stage 1 was compared with height measurements taken in subsequent stages to find out if poorer seedlings can be culled early if necessary. The analysis is presented in Table 8. Similar comparisons were also made in relation to the diameter as shown in the same table.

In both instances it is evident that the early measurement is a fairly good index of subsequent growth, although the relationship becomes weaker when the dates of comparison are wider apart. The lower coefficient even after five months of growth was + 0·6674 for comparisons of height and + 0·6720 for comparisons of diameter. Therefore rootstock vigour measured as the height or diameter during an early stage of growth can be regarded as an efficient culling criterion. Even in this instance therefore the diameter can be selected as a convenient growth parameter.

Data available so far seem to suggest that the late germinators are poor in rootstock vigour. This may be related to genetical factors. Whether this difference in rootstock vigour which is measured in the nursery has an influence on subsequent vegetative vigour and yielding ability of budded plant has yet to be determined.

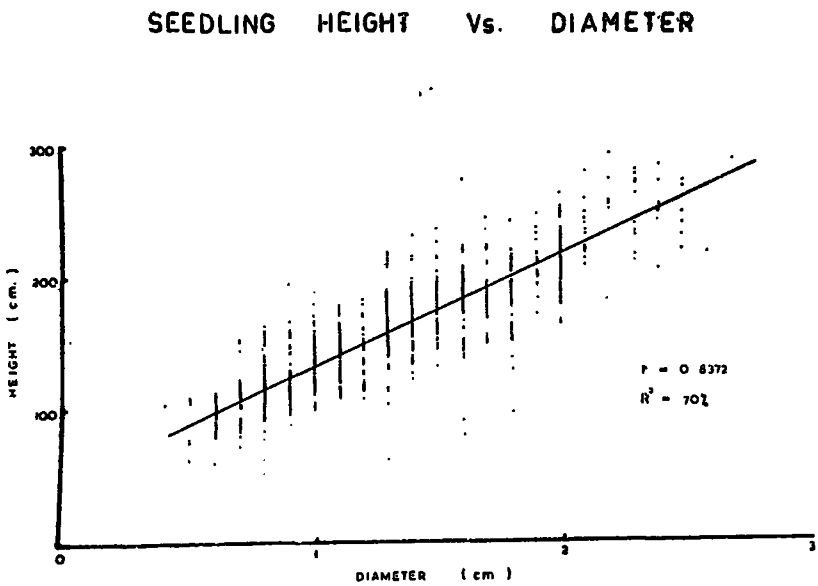

Fig. 5 Relationships between seedling height and diameter.

TABLE 8

CORRELATIONS OF HEIGHT AND DIAMETER OF EARLY STAGES WITH SUBSEQUENT STAGES OF GROWTH

		Correlations
Height (Stage 1)	× Height (Stage 2)	+0·8938
	× Height (Stage 3)	+0·7758
	× Height (Stage 4)	+0·7201
	× Height (Stage 5)	+0·6674
Diameter (Stage 2)	× Diameter (Stage 3)	+0·7362
	× Diameter (Stage 4)	+0·7234
	× Diameter (Stage 5)	+0·6720

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QUESTIONS AND ANSWERS

Question: Why not we find out a stock resistant to root disease? (Mr. Frank L. de Silva)

Answer: There is evidence to show that there is a relationship between vigour and disease resistance but we have not started any work with regard to the resistance of *Hevea* rootstock to root diseases.

Question: You suggest culling on the basis of height and diameter. The planter will not be able to do a job of this nature like a research worker. Therefore would you suggest that culling on purely visual evidence is sufficient ? (Anon)

Answer: According to the data collected so far, there is a correlation between germination period and growth of other morphological characters such as diameter and height. If this relationship exists up to budding stage, period of germination which could be observed visually can be used for culling.