Age trends in the genetic control of production traits in *Hevea*

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ABSTRACT

Seven clones were studied, at four locations ,in replicated trials, in São Paulo State, Brazil, to determine the nature and extent of the genetic and environmental control of yield and girth traits in rubber tree [*Hevea brasiliensis* (Willd. ex Adr. de Juss.) Muell.-Arg.]. The clones represented a range of recommended material for planting, whereas the locations were selected to represent a range of rubber growing areas. Trees were studied for yield and girth over 11 years including three years after the initiation of tapping for latex: girth, vigor, and rubber yield. Girth analyses data showed a consistent increase in genotype component over the pre-tapping stage from 16 percent to 40 percent, with a corresponding decrease in the effect of the environment (71 percent to 38 percent). With respect to yield there was a similar change from environmental control to genetic control of the trait over the three years during which yield was monitored. Correlations between final tree size and earlier measurements indicate that different genes are involved in pre- and post-tapping growth. This implies that post-tapping size measurements alone are useful as predictors of final size. There are non significant but negative correlations between vigour and rubber production. The implications of these findings to breeding and selection of rubber for these two production traits are discussed.

KEYWORDS: *Hevea brasiliensis,* yield, vigour, variances components.

INTRODUCTION

Rubber tree [*Hevea brasiliensis* Willd. ex Adr. de Juss.) Muell. Arg.] is one of the newest plantation crop in Sao Paulo. The total extent of cultivated rubber has been estimated to be around 50 thousand hectares in 2001 and the rubber industry provides employment directly to about 14 thousand in the field. Sao Paulo's total production of rubber in 2001 was estimated in 47 thousands tons. (Gonçalves, 2002).

Rubber in Sao Paulo is generally grown in the Plateau region mainly at altitudes around 500m. A small amount of rubber is also grown in the intermediate rainfall zone (e.g. Ribeira river valley), which receive more rain. (Ortolani et al., 1998)

Rubber trees are grown for their latex from which rubber is coagulated and processed and hence it is the dry rubber yield which determines the level of output. Girth is an economically important character and is considered to be a measure of vigour. It determines the age at which a clone could be exploited and is therefore important in shortening the uneconomic, immature period. Furthermore, large trunks have more timber value.

Yield and vigour, as measured by dry rubber content and girth respectively, are two of the three most important selection criteria in any *Hevea* breeding program. The third criterion is tolerance to important diseases.

Genotypic (G), environment (E) and genotype x environment interaction (G x E) are the three main components of variability in any population. The relative magnitudes of these not only determine the response to selection but also the method of selection in any breeding program. Thus a knowledge of these components of variation is of great value to the breeders. There are few previous reports on studies of these genetic aspects of rubber (Jayassekera et al., 1994; Gonçalves et al 1998a; Costa et al., 2000) although the importance of a knowledge of the adaptability of rubber clones to the diverse agro-climatic and soil conditions under which rubber is grown has been stressed.

Therefore, in 1990 an experimental trial was designed to study the G, E and G x E in *Hevea* with respect to the production traits, girth and rubber yield. Early fifth and sixth year data collected from this experiment have been analyzed and reported previously (Gonçalves et al., 1998 a, 1998b).

The present paper reports results of the analyses of girth, collected over a 11 year period, and yield data, collected during the first three years of tapping, from this trial and shows how relative contributions of genetic, environmental and genotypic x location interaction components change over the time.

MATERIAL AND METHODS

Genetic material

The genetic material originally consisted of seven *Hevea* clones, which are listed, in Table 1.

They were chosen to represent good clones available at the time of establishing this experiment. Some clone such as PR 261, PR 255, GT 1, RRIM 600 and IAN 873 were recommended clones, whereas some others had been used as parents in rubber breeding programs in the State of Sao Paulo. One clone, PB 217, had to be removed from the analysis of data because it was found to be of very poor growth and low survival. One and half-year old rootstock seedlings raised in nurseries were used to bud graft clonal materials. Bud grafting was made in December 1989. The successful bud grafts were uprooted and planted in polyethylene bags. After the first emission of flush leaves the experiments were placed in the field.

Plants were spaced at 7.00m between rows and 3.00m within the row. Chemical analysis was performed on the arable layer of these soils (Table 2). The experimental plots were fertilized with NPK mixture applied according to recommendations of the Instituto Agronomico (Cardoso, 1989). Missing plants were replaced with spares during the first two years after planting to maintain the plantation density, but were not scored.

The locations

The experiments were conducted at four different locations chosen to represent different rubber planting districts (Table 3). Part of the experiments were located on private farms and part at Experimental stations of the Instituto Agronomico. They are representative of the most important non-traditional area, of continental climate, of rubber production in Brazil.

The experimental design at each test location was randomized complete blocks with three replications. Thirty plants were used in each plot in all locations except Votuporanga. At Votuporanga, a smaller plot size of twenty plants was used. Plots thus consisted of five rows of six or eight plants each.

Measurements

Vigour in terms of girth (annual) of each tree was measured. In the first year diameter was recorded,

Table 1. List of rubber clones, parentage places of origin mean final girth and mean annual yield of seven *Hevea* clones evaluated in four different locations in the State of São Paulo, Brazil.

Clones[1/]	Parentage	Origin	Mean final girth (cm)	Mean annual yield (g)[3/]
GT 1	Primary clone	Indonesia	58.04 ± 1.84	34.75 ± 3.05
PR 261	Tjir 1 x PR 107	Indonesia	55.43 ± 2.35	26.73 ± 2.98
PR 255	Tjir 1 x PR 107	Indonesia	53.30 ± 1.88	38.26 ± 3.01
IAN 873	Pb 86 x FA 1717	Brazil	54.88 ± 1.94	31.73 ± 2.66
RRIM 701	44/553 x RRIM 501	Malaysia	52.53 ± 2.29	33.28 ± 2.84
PB 235	PB 5/51 x PB S.78	Malaysia	54.27 ± 1.88	51.01 ± 2.19
RRIM 600[2/]	Tjir 1 x PB 86	Malaysia	52.80 ± 1.57	39.59 ± 2.19

[1/] GT: Godang Tapen; RRIM: Rubber Research Institute of Malaysia; IAN: Instituto Agronômico do Norte; PR: Proefstation voor Rubber; PB: Prang Besar; Tjir: Tjirandji; FA: Ford Acre; [2/] Control clone; [3/] Per tapping, per tree, mean of tree years.

Table 2. Soil sample chemical analyses obtained from four different locations, where seven clones of *Hevea* were evaluated in São Paulo State, Brazil [1/].

Determinations	Locations			
	Indiana	Votuporanga	Mococa	Ribeirão Preto
P resin (mg/kg)	4.00	4.00	4.00	2.60
O.M. (g/kg)	1.00	1.30	2.20	2.60
pH ($CaCl_2$)	3.80	4.00	4.10	5.00
K^+ (mmol/cm^3)	0.06	0.22	0.31	0.12
Ca^{2+}(mmol/cm^3)	0.10	0.60	0.80	2.10
Mg^{2+}(mmol/cm^3)	0.10	0.40	0.40	1.00
$H^+ + Al^{3+}$(mmol/cm^3)	2.50	3.60	5.20	3.80
S (mmol/cm^3)	0.30	1.20	1.50	3.20
CEC (mmol/cm^3)	2.80	5.00	6.70	7.00
V%	9.00	24.00	23.00	46.00
B (mg/kg)	0.10	0.20	0.20	0.20
Cu (mg/kg)	0.50	0.70	1.70	6.10
Fe (mg/kg)	26.40	28.00	44.80	13.20
Mn(mg/kg)	19.00	39.10	25.30	37.70
Zn (mg/kg)	0.60	1.40	1.50	0.70

[1/] P resin: Resin extractable phosphorus; O.M.: Organic matter; S: Sum of bases; CEC: Cation-exchange capacity; V%: Percentual of soil base saturation

Table 3. Details of experimental locations and planting dates from four different locations where seven *Hevea* clones were evaluated in São Paulo State, Brazil.

Remarks	Locations			
	Mococa	Ribeirão Preto	Votuporanga	Indiana
Year of planting	1989	1989	1989	1989
Planting material	Budded stumps	Budded stumps	Budded stumps	Budded stumps
Spacing (m)	7.00 x 3.00	7.00 x 3.00	7.00 x 3.00	7.00 x 3.00
Planting density	5 rows x 6 trees	5 rows x 6 trees	5 rows x 8 trees	5 rows x 6 trees
	30 trees/plot	30 trees/plot	40 trees/plot	30 trees/plot
Design of experiment	RBD[1/]	RBD	RBD	RBD
Numbers of replications	3	3	3	3
Total area (ha)	2	2	2	2
Elevation (m) (mean sea level)	665	467	450	621
Latitude (S)	21º28'	22º11'	20º25'	32º21'
Longitude (EE)	47º01'	47º48'	49º50'	51º30'
Temperature (annual mean)	24,5ºC	29,10ºC	22,3ºC	28,10ºC
Annual rainfall (mm) (mean annual)	1500	1534	1480	1257
Soil type[2/]	Eutrustox	Kandiudox	Paleudalf	Paleudalf
Terrain	Flat to undulating	Flat to undulating	Flat	Flat

[1/] Randomized block design; [2/] In accordance with Brazil (1960); [3/] Clay soils with indistinct horizon differentiation developed from basic igneous rocks. The soils are slightly acid to neutral with high base saturation and high contents of iron oxides.

because plants were to small to measure girth. Measurements were converted into the diameter of the plants was measured 0.50m above around level by a slides caliper.

Trees that reached a girth of 45.0 cm or more were opened for tapping at a height of 1.20 m above the bud union. The used tapping system was ½ S d/4 6 d/7. ET 2.5% (a half spiral cut tapped in each four days, six day in tapping followed by one day of rest, stimulated with 2.5% ethefon) Yield was recorded on the days when normal tapping, which starts around 6:30 AM, was possible. After tapping, latex was allowed to collect in plastic cups provided for each recording tree. Once the latex was flow was stopped, rubber was coagulated in the cup itself by adding two percent of acetic acid solution and stirring it well. The coagulated rubber in each cup was them made into a "biscuit" which were dried ranged by a wire tied in each tree for about 30 days, was weighed and the dry rubber content for each tree was recorded.

Biotatistical analyses

All the analyses of vigour were performed on pre- and post-tapping annual girth data from seven (pre-) and four years (post-tapping) of growth respectively. Firstly a two-factor analyses of variance (Table 4) was carried out on the data collected from each year, and analyzed separately.

These clones and years were the main source of variation. In the case of yield data, only those years with six or more test tappings in corresponding months for all locations were analyzed. For all genotype locations combined the statistical model used was:

$$Y_{ijk} = \mu + G_i + P_j + (GP)_{ij} + R_{k(j)} + E_{ijk} \text{ where,}$$

Y_{ijk} is the observation on the *i*th genotype (clone) in the *j*th location in *k*th replication;

μ is the general mean;

G_i is the fixed effect of the *i*th genotype;

P_j is the effects of the *j*th location;

$(GP)_{ij}$ is the interaction of the *i*th location;

$R_{k(j)}$ is the effect of *k*th randomized block within the *j*th location;

E_{ijk} is the experimental error associated within the *ijk*th observation.

A there-factor analyses of variance (Table 5) was performed on data collected from all locations and years. The model underlying the analysis may be written as:

$$Y_{ijkl} = \mu + G_i + P_j + T_k + (GP)_{ij} + (GT)_{jk} + (PT)_{jk} + (GPT)_{ijk} + E_{ijkl}$$

where, Y_{ijkl} is the *l*th observation on the *i*th clone in the *j*th place in the *k*th year. The first four terms on the right hand side are the mean and the main effects of genotypes (clones), locations and times (year); the next three terms are the first order interactions, then the second order interaction and finally the micro-

Table 4. Degree of freedom (D.F.), mean square (M. S.) and expected mean square (E.M.S.) for two-factor analysis of variance [1/].

Source of variations	D.F.	M.S.	F	E.M.S.
Repetition/locations	p (r-1)	M_1	M_1/M_2	$\sigma_E^2 + g\sigma_R^2$
Locations (P)	p-1	M_2	M_2/M_5	$\sigma_E^2 + g\sigma_R^2 + rgV_P$
Genotypes (G)	g-1	M_3	M_3/M_5	$\sigma_E^2 + rpV_G$
G x P	(g-1) (p-1)	M_4	M_4/M_5	$\sigma_E^2 + + rV_{GP}$
Residual (mean)	p(g-1) (r-1)	M_5	-	σ_E^2

[1/] p, g and r: number of locations, genotypes and replications respectively; V_P: variance due to location differences; $V_{G:}$ Variance due to clonal differences; $V_{GP:}$ Variance due to clone x location interactions; σ_E^2: environmental variance among plots.

environmental deviation within locations and years. It usually assumed, perhaps gratuitously, that genotypes (clones), and places could all be regarded as fixed effects and years random effects, so that the model is a mixed effects model. The analysis of variance is shown algebraically in Table 5, on the assumption that *g* genotypes have been tested in *p* locations for *y* years with *r* replications.

Correlations coefficient (r) between mean girth of the seven clones for each pre- and pos- tapping year and mean yield over the three years were calculated.

RESULTS AND DISCUSSION

Genetic variation

The mean girth and mean annual yield per tapping, per tree of the seven clones measured are shown in Table 1. Girth mean were generally higher for clone GT 1. Clone RRIM 600 the most planted genotype in the State São Paulo, together with RRIM 701 had the worst girth performance (52.53 cm) and yield average of 36.48 g/tapping/tree. The lowest yielding clone was PR 261, while the highest yielding one was PB 235 i.e. 191% more productive.

Variance components

The significant components of the three-factor analysis of variance are tabulated in Table 6 in which it is seen that the second order interaction was not significant for post-tapping girth. Similar results were found by Jayasekera et al. (1994) in Sri Lanka at seven locations.

In the case of yield, all main effects and their interactions, both first- and second-order, turned out to be significant in the three-factor analysis of variance. Significant components have been estimated and are presented in Table 6. To remove the year effect from the analysis in order to study

Table 5. Scheme of pooled analysis of variance degree of freedom (D.F.), mean square (M.S.) and expected mean square (E.M.S.) for three-factor analyses of variance [1/].

Source of variations	D.F.	M.S.	F	E.M.S.
Replication (P/Y)	py (r-1)	M_1	M_1/M_9	$\sigma_E^2 + g\,\sigma_R^2$
Locations (P)	p-1	M_2	M_2/M_4	$\sigma_E^2 + g\,\sigma_R^2 + \frac{p}{p-1} rg\sigma_{PY}^2 + ryg\,V_P$
Years (Y)	y-1	M_3	M_3/M_1	$\sigma_E^2 + g\,\sigma_R^2 + rpg\sigma_y^2$
P x Y	(p-1) (y-1)	M_4	M_4/M_1	$\sigma_E^2 + g\,\sigma_R^2 + \frac{p}{p-1} rg\,\sigma_{PY}^2$
Genotypes (G)	(g-1)	M_5	M_5/M_7	$\sigma_E^2 + \frac{g}{g-1} rp\,\sigma_{GY}^2 + rpy\,V_G$
G x P	(g-1) (p-1)	M_6	M_6/M_8	$\sigma_E^2 + \frac{g}{g-1} \cdot \frac{p}{p-1} r\sigma_{GPY}^2 + ryV_{GP}$
G x Y	(g-1) (y-1)	M_7	M_7/M_9	$\sigma_E^2 + \frac{g}{g-1} rp\,\sigma_{GY}^2$
G x P x Y	(g-1) (p-1) (y-1)	M_8	M_8/M_9	$\sigma_E^2 + \frac{g}{g-1} . \frac{p}{p-1} r\,\sigma_{GPY}^2$
Residual (mean)	(r-1) (g-1) yp	M_9		σ_E^2

[1/] p, y, r and g: number of locations, years, replications and genotypes respectively; σ_E^2 : environmental variance among plots, σ_{PY}^2 : variance due to genotypes x locations x years interactions; σ_{GY}^2 : variance due to genotypes x years interaction; σ_{GP}^2 : variance due to genotypes x locations interactions; V_G : variance due to clonal differences; σ_{PY}^2 : variance due to location x years interactions; σ_Y^2 : variance due to years differences; V_P : variance due to location difference and σ_R^2 : variance due to replication within location and years.

Table 6. Degrees of freedom (d.f.), mean squares (M.S.) estimates of variance components (σ^2) and degree of significance (p) for three-factor analysis of variance of annual girth (pre- and post-tapping) and annual yield of seven *Hevea* clones evaluated in four different locations in the State of São Paulo, Brazil.

Source of variation	Girth								Yield			
	Pre-tapping				Post-tapping							
	d.f.	M.S.	σ^2	p	d.f.	M.S.	σ^2	p	d.f.	M.S.	σ^2	p
Replications (P/Y)	56	3.7873	0.18	ns	32	18.05771	0.03	ns	24	9.8856	1.19	ns
Locations (P)	3	2,679.0091	17.70	2/	3	705.70	21.17	2/	3	14,271.3367	206.38	2/
Years (Y)	6	15,077.2059	179.71	2/	3	1,554.1021	18.28	2/	2	188.9193	2.13	2/
P x Y	18	76.5061	2.50	2/	9	112.9123	3.37	2/	6	1269.6147	59.99	2/
Genotypes (G)	6	204.5955	2.31	2/	6	235.4810	4.29	2/	6	1980.4258	53.98	2/
G x P	18	42.8107	1.77	2/	18	54.1425	1.77	2/	18	253.8945	23.88	2/
G x Y	36	10.4146	0.38	2/	18	6.9002	0.81	2/	12	37.2507	1.36	1/
G x P x Y	108	5.4904	0.08	2/	54	3.6874	3.14	ns	36	32.9808	4.45	2/
Residual	336	5.1080	5.10	-	192	18.2883	18.28	-	144	18.2148	18.21	-

n.s.: non significant; 1/ $p < 0.05$; 2/ $p < 0.01$.

Table 7. Estimates of genotypic (V_G^2), environmental (σ_E^2) and genotype x location (V_{GP}^2) components of annual girth increment (pre- and post-tapping) and annual yield of seven *Hevea* clones evaluated in four different locations in the state of São Paulo, Brazil.

Year	V_G^2	σ_E^2	V_{GP}^2
	Pre-tapping		
1st	0.0732	0.3247	0.0602
2nd	0.5927	0.7657	0.2946
3nd	1.3327	1.7559	1.2793
4th	3.2626	3.8452	1.6728
5th	4.3974	4.7455	2.5331
6th	5.3286	3.2086	4.7418
7th	6.1777	6.1121	4.5820
	Post-tapping		
8th	7.7767	24.7683	3.5468
9th	5.4421	36.3829	8.2317
10th	5.1326	6.3956	5.1346
11th	3.1648	5.6067	1.4083
	Yield		
1st	46.9216	20.2032	31.8533
2nd	57.5488	21.6215	19.4821
3nd	58.0582	24.8198	16.2349

genotypic, and environmental (location) factors and their interaction effects in more detail, a two-factor analyses of variance was carried out for girth and yield for each year separately. Genotypic, environmental (locations) and genotype x location interaction variance components for each year were estimated from the two-factor analyses and are presented in Table 7 separated for pre- and post-tapping girth and yield. In contrast to girth (Table 7) the yield year effect is small compared with locations and genotypes.

Components contribution

The percentage contributions of these components to the total variation were also estimated and are presented in each annual assessment as to girth (Figure 1) and annual yield (Figure 2).

In the first year, the genetic component of girth was only 16 percent and was the smallest component when compared with the others components i.e. location 71 percent and genotype x location 13 percent. But it can be seen from Figure 1 that over the years, mainly in pre-tapping stage, genetic component increases at the expense of the environment (locations) component and decreased 11 percent in the second year of post-tapping. The environmental (locations) component which contributed 71 percent to the total variation in the first year contributed only 36 percent in the 7th year of planting (pre-tapping). On the other hand a great environmental variance percentage value was observed in the post-tapping stage, possibly due to the tapping processing. In general after the panel opening this contributes to the reduction of the girth increment in some clones. Additionally, the photosynthetic energy is distributed between two competing sources i.e. exploited latex and girth increment. In some clones, the photosynthetic energy goes almost completely toward replenishing the exploited latex, thus reducing the girth growth (Wicherley, 1976). All these physiological disturbances could contribute toward these great environmental variance values.

The genotype x location interaction component also decreased from 13 percent in the first year to 14 percent in the 11th year. This increase is until the 6th year, as was found in the other two components, and fluctuating there are fluctuations over the years. By about the 7th year, the contribution of genotype x location interaction becomes inconsistent at between 10 and 32 percent,

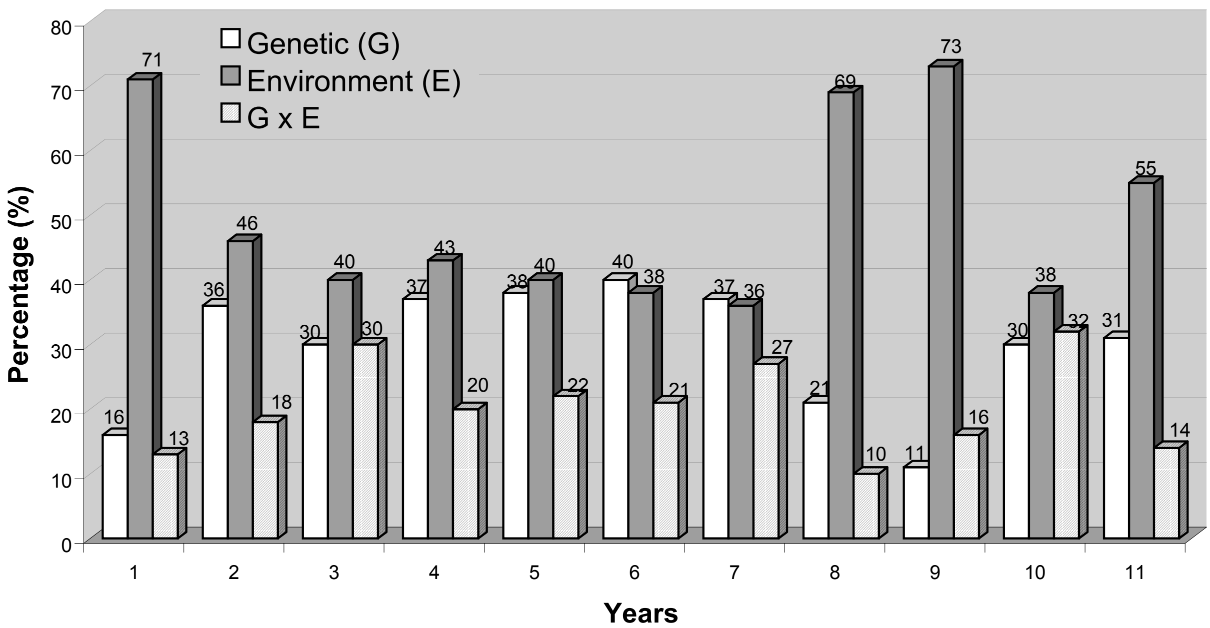

Figure 1. Change of genetic, environment and genotypic x environment interaction (G x E) components over years for girth.

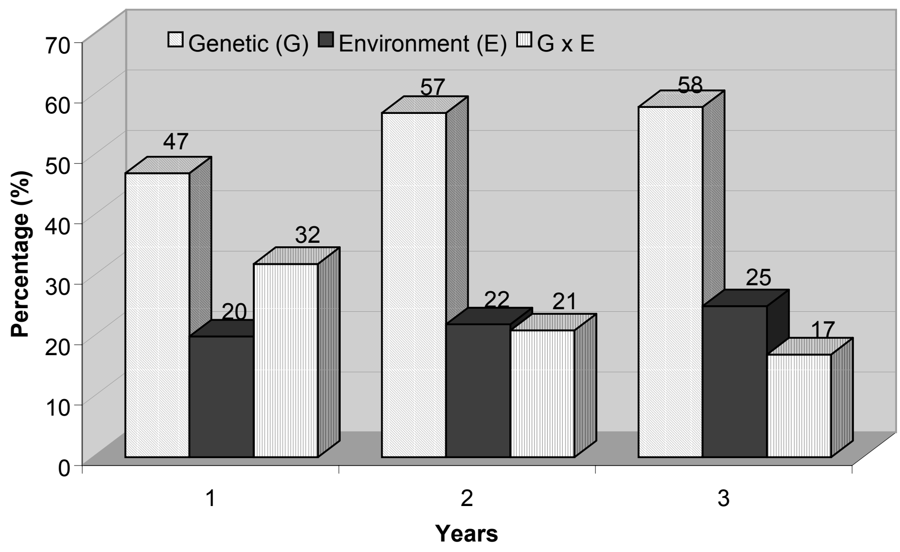

Figure 2. Change of genetic, environment and genotype x environment interaction (G x E) components over years for yield of dry rubber in *Hevea*.

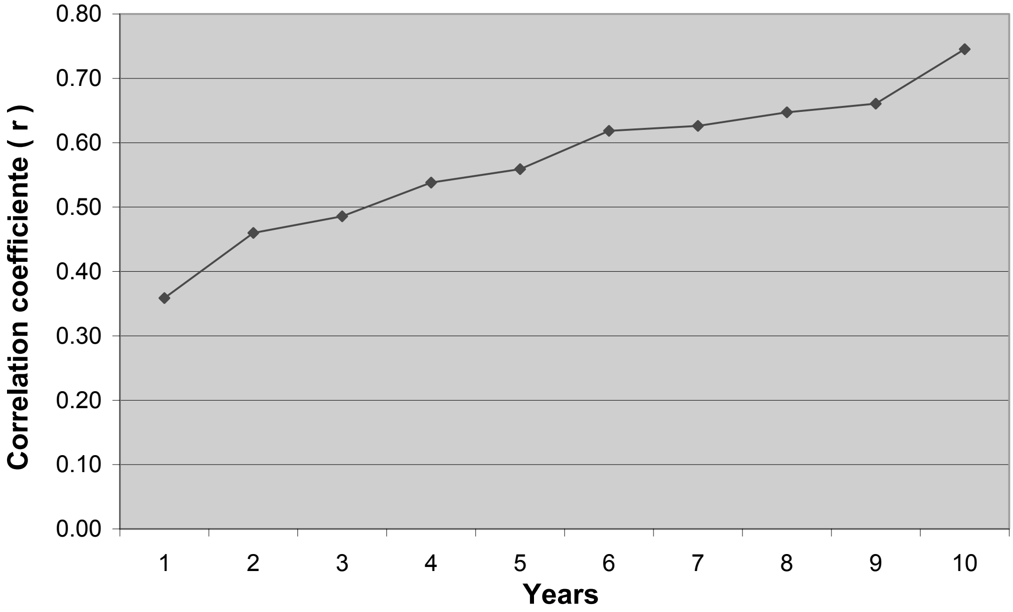

Figure 3. Correlation coefficient (*r*) between year 11 and other years for girth.

maybe due to the physiological the stress that the trees are submitted to by the tapping process.

The significant level and the percentage of contributions to the total variation by these three components for yielding are in Figure 2. In it can be seen that the contribution of genetic and environmental components are more or less the same for all three years under consideration, in marked contrast to girth. The genotype x location interaction component was the highest in the first year and small component in the following years and its contribution was only about half the genetic component.

Correlations

To explore the possibility of early selection for vigour, the correlation between clones for final (11^{th} year) girth with their girth in other years were studied. These correlations are shown graphically in Figure 3. It can be seen that although the correlations with year 1 is quite low (r = 0.35), it increases to a maximum between years 9 and 10. These correlations show that a fairly reliable early prediction of the 11^{th} year girth could be made by the second year and the reliability of the prediction gradually increases from the second year onwards. However the consistence of the correlation along the years requires explanation. To this end the changes in girth over time were examined in several clones (RRIM 600, GT1, PR 261, P 255 and IAN 873). This clearly indicates that the growth behavior of different clones did not change markedly after tapping such that some initially fast growing genotypes may be slower growing, relative to other genotypes, post- tapping. This pattern would explain the fair correlations with pre - tapping and post-tapping along with the 11 year.

Correlations between annual pre- and post-tapping girth with mean yield (over years) of clones not significant (Table 7). The correlation coefficients had negative signs ranging between r = -0.09664 and r = -0.52151. These results indicate that girth cannot be considered as a good predictor of yield and this is especially true for pre- and post-tapping girth where the correlations were lowest.

Final considerations

This study clearly indicates that there are genetic differences between clones in both yield and vigour. In the very early years, locations are the major influence on the expression of girth but as the plant age, genetic control increases and by the post-tapping year these effects dominate. Although significant, the effects of genotype x location interaction are minor and increase with the time in the pre-tapping stage. This is a not surprising result, given the wide range of locations used and emphasizes the over-riding importance of the genotype. Correlation analyses between mean girth measurements of different years indicate years indicate that early selection for final girth would be possible only from the eighth after year planting. The change in mean girth of different

Table 8. Estimates of genotypic correlation coefficients among annual girth and annual yield of seven *Hevea* clones evaluated in four different locations in the São Paulo State, Brazil.

Annual Girth	Annual girth										Annual yield		
	2nd	3nd	4th	5th	6th	7th	8th	9th	10th	11th	1th	2nd	3nd
1st	0.8767[2/]	0.8596[2/]	0.7972[1/]	0.7736[2/]	0.7120[2/]	0.7018[2/]	0.6250[2/]	0.6636[2/]	0.9397[2/]	0.3588 n.s.	-0.17237n.s.	-0.09664n.s.	-0.23209n.s..
2nd	1	0.9427[2/]	0.8775[1/]	0.9013[2/]	0.8783[2/]	0.8630[2/]	0.7688[2/]	0.8064[2/]	0.8096[2/]	0.5630[2/]	-0.16072n.s.	-0.10311n.s.	-0.20778n.s.
3nd		1	0.9404[1/]	0.9180[2/]	0.9164[2/]	0.9063[2/]	0.8281[2/]	0.8540[2/]	0.8120[2/]	0.4857[1/]	-0.24262n.s.	-0.20143n.s.	-0.23745n.s.
4th			1	0.8830[2/]	0.8803[2/]	0.8844[2/]	0.8246[2/]	0.8214[2/]	0.8157[2/]	0.5380[1/]	-0.38491n.s.	-0.34662n.s.	-0.35629n.s.
5th				1	0.9482[2/]	0.9549[2/]	0.8605[2/]	0.9169[2/]	0.8397[2/]	0.5448[1/]	-0.37266n.s.	-0.26075n.s.	-0.34490n.s.
6th					1	0.9796[2/]	0.9276[2/]	0.9501[2/]	0.9100[2/]	0.6185[2/]	-0.34748n.s.	-0.26277n.s.	-0.29042n.s.
7th						1	0.9454[2/]	0.9743[2/]	0.9249[2/]	0.6262[2/]	-0.43801n.s.	-0.34006n.s.	-0.37236n.s.
8th							1	0.9491[2/]	0.9152[2/]	0.7829[2/]	-0.42988n.s.	-0.33411n.s.	-0.34462n.s.
9th								1	0.9319[2/]	0.6606[2/]	-0.52151n.s.	-0.42844n.s.	-0.46583n.s.
10th									1	0.7453[2/]	-0.48932n.s.	-0.38799n.s.	-0.42659n.s.
11th										1	-0.25250n.s.	-0.17125n.s.	-0.26096n.s.

[1/] $p < 0.05$; [2/] $p < 0.01$; n.s.: non-significant.

clones over years suggested that the relative growth between clones changes after tapping, i.e. clones, which initially grow fast, may grow slowly post-tapping relative to others. These findings lead to the conclusion that selection for final vigour should be delayed at least until the eight year from planting.

In the case of yield, there are no apparent reversals from environmental to genetic control and the relative importance of G, E and G x E remained constant. As only three years of yield data have been and analyzed it is premature to comment on the optimum stage for early prediction for yield. However, the correlation studies indicated that girth cannot be used as an indicator of yield potential genotypes.

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RESUMO

Influência da idade no controle genético dos caracteres de produção em *Hevea*.

Com objetivo de determinar a natureza da grandeza e controle genético e ambiental do vigor e produção da seringueira [*Hevea brasiliensis* (Willd. ex Adr. de Juss.) Muell.-Arg.] sete clones foram estudados em quatro diferentes locais do Estado de São Paulo. Os clones, na sua maioria, são de origem asiática, e os locais selecionados representam as diferentes regiões da heveicultura do Estado. O perímetro do caule e produção de cada local foi obtido por um período de 11 anos e três anos respectivamente. Os resultados das análises de perímetro mostraram um aumento constante do componente genético na pré-sangria fase anterior a sangria de 16.0 a 40.0 porcento com um decréscimo correspondente no efeito do ambiente de 71.0 a 38.0 porcento. A produção não apresentou alteração do controle genético e ambiental nos três anos de avaliação. Correlações genéticas entre a última e as mensurações anteriores do perímetro do caule mostraram que diferentes genes estão envolvidos no crescimento das fases pré e pós-sangria mostrando que os primeiros anos de avaliação do perímetro na pré-sangria são suficientes para predizer o vigor dos últimos anos dos perímetros do caule. As correlações entre vigor e produção foram negativas e não significativas. As implicações dos resultados em relação ao melhoramento e seleção da seringueira em relação a vigor e produção são discutidos.

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