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Relationships among yield, girth and some structural characters of the laticiferous system in young seedlings of Rubber trees (*Hevea*)

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ABSTRACT

The aim of the present investigation was to examine the relationship between growth, yield and characters of the laticiferous system of seedlings at the nursery stage. The main objectives were to seek information concerning the extent these characters are independent of each other and establish among the studied characters the principal ones that determine the yield.

Thirty seedlings at the nursery stage of [*Hevea brasiliensis* (Willd. ex Adr. de Juss.) Müell.Arg.], with yield levels ranging from high to low, were evaluated for juvenile growth (G), yield (Y) and bark structural characters to identify early selection parameters. The bark structural characters studied were: bark thickness (BT), total number of latex vessel rings (LV), overall density of latex vessels per ring per five square millimeters of bark (DV), average diameter of latex vessels (DL) and average distance between consecutive latex vessel rings (AD). The results showed significant linear correlations between Y and LV or DV. No correlations were detected, however, between Y and G or BT. The correlations between G and BT were positive and significant. Multiple regression studies of Y on DV, LV, DL, BT and G suggest that DV and DL, through non-significant, jointly accounted for 49% of the variation on Y. When G was used as the dependent variable, with BT and DV as independent variables, BT was the only important and significant variable, accounting for 41% of the variation on G. Studies of LV on AD or Y, shows that AD and Y were the dominant and significant variables accounting for 39% and 17% of the variation in LV. Girth and bark thickness do not appear to give significant positive predictive power for LV.

INTRODUCTION

Rubber [*Hevea brasiliensis* (Willd. ex Adr. de Juss.) Müell. Arg.] is indigenous of tropical rain forest in the Amazon Basin. It is cultivated in many tropical countries, most of which have active plant breeding programmes. Yield is the most important character considered in the selection of rubber cultivars for planting, a complex polygenic character that is dependent on a number of components (Licy and Premakumari, 1988). Due to the long timespan required to produce acceptable cultivars a knowledge of the association of quantitative characters, especially of yield and its attributes, would be of immense practical value in crop breeding programmes. An early prediction method would help reduce the population size for further evaluations, thereby bringing down the cost and

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time required for release of high yielding cultivars. An effective method would be to relate the yield of trees with characters of laticiferous system that could be measured readily at the nursery stage. With such information a more effective approach to breeding, selection and exploitation of rubber could be divised. The laticiferous system is both the storage region from which latex is released on tapping and the site of the final stages of rubber synthesis in *Hevea* (Southorn, 1966; Gomez, 1966; Dickenson, 1969). Its structure is hence of direct relevance to productivity.

Among the characters of the laticiferous system many studied have been carried out in relation to latex vessels. Ashplant (1928) proposed the use of the number of rings of laticifers, which might forecast production of the adult tree. Later Gunnery (1935), found a relationship between the diameter of sieve tubes and production potential of trees and proposed the use of this observation for selective discarding from a population of one-year-old seedlings. In Malaysia, Narayanan *et al.* (1973) studied yields of young trees and other characters associated with the laticiferous system in 80 clones from five different regions and observed that these characters were unrelated and contribute independently to the yield of nursery buddings. At the same time Narayanan *et al.* (1974) carried out correlations studied between yield girth and structural factors of the laticiferous system on 11 year-old-clones, and observed that girth and latex vessel ring number were important in determining yield. A complete view about the use of anatomical characteristics of the laticiferous system in relation to early selection is provided by Fay and Jacob (1988).

MATERIAL AND METHODS

Data used in this study were collected from 30 young *Hevea* ''ortets'', the original ancestors of vegetatively propagated clones, selected on the basis of similarities in yield performance from a juvenile tree population established at the Pindorama Experimental Station, Pindorama city, São Paulo state, Brazil (altitude 560 m, latitude: 21°13' South, longitude: 48°56' West).

At three years old the ortets were submitted to yield determination, using the Hamaker Morris-Mann technique (Tan and Subramaniam, 1976). Thirty-five tappings were made on half spiral alternate daily (1/2 S 1/2 d) tapped at 20 cm from the ground. Yield recording was done by cup coagulation. The ''biscuits'' were air dried for two months, until they gave constant weight. The result of ortet performance was expressed in grams per tree tapping. Girth measurements were taken at the same time also at 20 cm from the plant base. Virgin bark samples were removed from the stem as plugs at 20 cm height, on the opposite side of the tapping panel.

Longitudinal and transverse sections were taken and stained with Sudam III and osmic acid to determine the following characters:

- Total number of latex vessel rings.
- Overall density of latex vessels per ring per five millimeters of bark.
- Average diameter of the latex vessels.
- Average distance between consecutive latex vessel rings.
- Bark thickness (mm) of samples collected for the above characters.

Means, standard deviations, coefficients of variation and simple correlations among the variables were calculated. Step-wise regression studies were also carried out to determine the contributions of various isolated variables or in combinations, to determine variations in yield, girth and total number of latex vessel rings.

RESULTS AND DISCUSSION

Means and variations

Yield means had the highest coefficient of variation (C.V.%) (Tables I and II). The C.V. values suggest that nursery yield has greater variation than girth. The number of latex vessel rings was also fairly variable among the seedlings studied.

Relationship studies

Simple correlations

The simple correlation coefficients among the characters studied are shown in Table III. The correlation coefficient between nursery yield and total number of latex vessel rings (LV) and overall density of latex vessels per ring per five square millimeters (DV) were positive and significant, while those between nursery yield (Y) and bark thickness (BT) and average diameter of the latex vessels (DL) were positive and not significant. The low, non-significant, correlation between girth and yield was the opposite of those results observed by Narayanan and Ho (1973). This probably is due to suppression of girth increment caused by tapping in high-yielding genotypes. After

Table I - Means for nursery yield in grams of dry rubber per plant tapping (Y), girth at nursery stage (G), bark thickness (BT), total number of latex vessels rings (LV), overall density of latex vessels per ring per five millimeters of bark (DV), average diameter of latex vessels (DL), and average distance between consecutive latex vessel rings (AD) of the bark sample taken from 30 three-year old *Hevea* seedlings.

Ortet		Parentage	Y (g/t/t)[1]	G (cm)	BT (mm)	LV (unit)	DV (unit)	DL (μ)	AD (μ)
Pind	177/88	RRIM 600 ill.	5.20	32.00	5.35	5	78.94	18.28	231.26
Pind	527/88	AVROS 363 ill.	3.78	32.00	4.40	5	87.72	27.42	261.71
Pind	157/88	RRIM 600 ill.	3.59	28.00	4.55	5	78.94	18.28	254.10
Pind	466/88	RRIM 513 ill.	3.38	32.00	5.10	5	70.18	25.59	288.36
Pind	634/88	PB 5/63 ill.	2.96	28.00	4.80	5	65.79	21.02	214.13
Pind	373/88	C 256 ill.	2.96	28.00	6.25	5	78.95	26.51	182.72
Pind	170/88	RRIM 600 ill.	2.90	24.00	4.00	3	70.17	19.89	354.02
Pind	673/88	Fx 3899 ill.	2.61	22.00	4.60	5	65.79	13.37	188.43
Pind	449/88	GT 711 ill.	2.58	26.50	4.75	3	61.40	17.37	479.64
Pind	609/88	Fx 3899 ill.	2.58	21.00	2.00	5	61.40	18.28	199.85
Pind	161/88	PB 86 ill.	2.56	26.00	3.55	4	61.40	18.28	247.43
Pind	218/88	PB 86 ill.	2.55	30.50	4.85	5	52.63	19.14	219.84
Pind	56/88	PB 86 ill.	2.48	25.50	3.25	4	31.57	27.42	236.01
Pind	654/88	GT 711 ill.	2.46	27.00	4.60	4	52.63	27.42	209.36
Pind	167/88	RRIM 600 ill.	2.44	21.50	3.80	4	48.27	21.99	247.33
Pind	144/88	Fx 652 ill.	2.42	34.50	6.15	5	52.63	22.85	228.40
Pind	163/88	PB 163 ill.	2.32	22.50	4.25	5	78.94	17.37	262.66
Pind	14/88	Fx 652 ill.	2.17	28.00	3.25	4	35.03	27.42	247.43
Pind	381/88	B 256 ill.	2.16	24.00	3.30	4	43.85	18.28	236.01
Pind	172/88	RRIM 600 ill.	1.91	36.00	6.00	3	48.24	17.37	236.01
Pind	512/88	PB 5/63 ill.	1.89	31.00	4.00	4	55.56	18.28	337.52
Pind	149/88	GA 363 ill.	1.88	22.30	3.53	6	48.24	18.28	203.28
Pind	257/88	IAC 2 ill.	1.87	32.50	4.03	3	43.85	13.71	365.44
Pind	637/88	PB 5/63 ill.	1.86	31.00	3.40	4	61.40	13.15	209.37
Pind	156/88	RRIM 600 ill.	1.86	28.50	4.45	4	61.40	12.85	220.79
Pind	555/88	C 256 ill.	1.85	27.50	3.95	4	52.63	18.28	266.47
Pind	462/88	PB 5/63 ill.	1.85	34.50	6.00	3	64.32	18.28	285.60
Pind	554/88	C 256 ill.	1.82	27.00	4.15	3	49.71	16.45	279.80
Pind	635/88	PB 5/63 ill.	1.82	25.50	3.90	3	52.63	18.28	354.62
Pind	302/88	Fx 25 ill.	1.80	26.00	3.70	3	52.13	17.36	274.08

(g/t/t)[1] grams of dry rubber per tree tapping.

panel opening, photosynthate is partitioned between two competing sinks: latex offtake and tree growth (Wycherley, 1975). So, high partition of assimilates towards yield in high-yielding genotypes, irrespective of their original vigour, would explain this behaviour.

Correlations between yield and total number of latex vessel rings were also demonstrated by Gonçalves *et al.* (1995) in progeny nurseries and Narayanan and Ho (1973) in clonal nurseries. This however contradicts the results of Gonçalves *et al.* (1984) and Lavorenti *et al.* (1990), who studied correlations within clones and progenies in the nursery stage. Narayanan *et al.* (1974) have also shown that within clones, girth, and bark thickness are related to total yield.

Multiple regression

Three sets of multiple regressions were made (Tables IV, V and VI). The first one (Table IV) used Y as

Table II - Overall means (x), range, standard deviations (S.D.) and coefficient of variation (CV%) of yield, girth bark thickness, total number of latex vessel rings, overall density of latex vessel per ring per five millimeters of bark, average diameter of latex vessels and average distance between consecutive latex vessel rings of the bark sample taken from 30 three-year old *Hevea* seedlings.

Character	Units	x	Range	S.D.	CV%
Yield	(g/t/t)[1]	2.484	1.80 - 5.20	0.751	30.24
Girth	cm	27.827	21.00 - 36.00	4.099	14.73
Bark thickness	mm	4.330	2.00 - 6.25	0.972	22.44
Total number of latex vessel rings	unit	4.060	3 - 5	0.433	10.67
Overal density of latex vessel per ring	unit	58.894	31.57 - 87.57	13.505	22.93
Average diameter of latex vessels	μ	20.082	13.15 - 27.42	4.064	20.24
Average distance between consecutive latex vessel rings	μ	260.722	182.72 - 479.64	63.686	24.43

g/t/t[1] - grams of dry rubber per tree tapping.

Table III - Simple linear correlations among yield nursery (Y), girth (G), bark thickness (BT), total number of latex vessel rings (LV), overall density of latex vessels per ring per five millimeters of bark (DV), average diameter of the latex vessels (DL) and average distance between consecutive latex rings (AD) of the bark sample taken from 30 three-year old *Hevea* seedlings.

Characters	G	BT	LV	DV	DL	AD
Y	0.1178^{ns}	0.2668^{ns}	0.4833**	0.6417**	0.2967^{ns}	-0.1241^{ns}
G		0.6437**	-0.1537^{ns}	0.0919^{ns}	0.0394^{ns}	0.0915^{ns}
BT			0.0386_{ns}	0.3711*	0.1559^{ns}	-0.0170^{ns}
LV				0.3777**	0.3021^{ns}	-0.6267**
DV					0.0139^{ns}	-0.0385^{ns}
DL						-0.2685^{ns}

Degrees of freedom = 28.
* = $P < 0.05$.
** = $P < 0.01$.
ns = not significant.

the dependent variable to see how much G, BT and the characters of the laticiferous system, i.e. DV, explain the variation in yield. The second one (Table V), used G as the dependent variable to see the contribution of BT in addition to the characters of the laticiferous system. The third one (Table VI), used the laticiferous system, i.e. LV as the dependent variable to determine the contribution of G and Y, in addition to the other components of the laticiferous system. In equations 1, 2 and 3 of the step-wise calculation of multiple regressions, where Y is the dependent variable (Table IV), DV and DL jointly or DV singly were able to account for 49% and 41% of yield variation, respectively. Inclusion of LV, an independent variable together with DV and DL improved the predictive power for yield to some extent. An increase of about 5% in the coefficient of determination was noted in the step-wise multiple regressions, suggesting that LV does not play an important rule in determining yield in young plants. In mature trees Ho *et al.* (1973) observed that LV is an important structural yield determinant. According to Wycherley (1969), between genotypes it accounts for as much as 25% - 50% of the variation in yield while within genotypes (clones) LV and G explain most of the variation in yield. In India, Licy and Premakumari (1988) explained 43% of variation in nursery yield by the LV, plant height, G and BT. In Malaysia nearly 80% of the variation in yield between clones at the nursery stage was accountable by BT, LV, girth increment and plugging index in the studies of Narayanan *et al.* (1974).

When G was the dependent variable, equations 4, 5 and 6 of the step-wise multiple regressions (Table V) show that BT accounted for 41% of the variation in G. Yield and the characters of the laticiferous system did not contribute significantly to the variation in G.

In equations 7, 8 and 9, where total number of LV is the dependent variable, average distance

Table IV - Stewise multiple regression of nursery yield (Y) on girth at nursery stage (G), bark thickness (BT), total number of latex vessels rings (LV), overall density of latex vessels per five millimeters of bark (DV), average diameter of latex vessels (DL), average distance between consecutive latex vessel (AD) of bark samples taken from 30 three-year old *Hevea* seedlings.

Equation	Dependent variable	Independent variable	Intercept	R^2
1	Y	0.0357** DV	0.3822	0.4112
		(0.0081)		
		0.0355** DV + 0.0532^{ns} DL	-0.6729	0.4946
		(0.0007) (0.0253)		
		0.0313** DV + 0.0421* DL + 0.3503^{ns} LV	-1.6250	0.5260
		(0.0082) (0.0263) (0.2668)		
		0.0303** DV + 0.0401^{ns} DL + 0.3926^{ns} LV + 0.0172^{ns} G	-2.1781	0.5343
		(0.0084) (0.0268) (0.2770) (0.0258)		
		0.0318* DV + 0.0422^{ns} DL + 0.3878^{ns} LV + 0.02624^{ns} G - 0.0630^{ns} BT	-2.2655	0.5374
		(0.0093) (0.0277) (0.2820) (0.0345) (0.1565)		
2	Y	0.0357** DV	0.3822	0.4112
		(0.0081)		
		0.0298** DV + 0.4869* LV	-1.2471	0.4794
		(0.0083) (0.2599)		
		0.0229** DV + 0.5317^{ns} LV + 0.0216^{ns} G	-1.9615	0.4926
		(0.0085) (0.2671) (0.0263)		
		0.0268** DV + 0.7046^{ns} LV + 0.0226^{ns} G + 0.0016^{ns} AD	-3.0092	0.5032
		(0.0089) (0.3583) (0.0265) (0.0022)		
		0.0270** DV + 0.7038^{ns} LV + 0.0237^{ns} G + 0.0016^{ns} AD - 0.0078^{ns} BT	-3.0116	0.5033
		(0.0099) (0.3661) (0.0357) (0.0023) (0.1601)		
3	Y	0.0357** DV	0.3822	0.4112
		(0.0081)		
		0.0355** DV + 0.0532* DL	-0.6729	0.4935
		(0.0076) (0.0253)		
		0.0352** DV + 0.0528* DL + 0.0089^{ns} G	-0.8982	0.4969
		(0.0078) (0.0257) (0.0256)		
		0.0368** DV + 0.0050* DL + 0.0193^{ns} G - 0.0720^{ns} BT	-1.0157	0.5009
		(0.0087) (0.0266) (0.0347) (0.1591)		
		0.0368** DV + 0.0534^{ns} DL + 0.0201^{ns} G = 0.0734^{ns} BT - 0.0004^{ns} AD	-0.8975	0.5019
		(0.0088) (0.0281) (0.0356) (0.1624) (0.0018)		

R^2 = Coefficient of determination.
* = P < 0.05.
** = P < 0.01.
ns = not significant.
Figures within brackets are the standard error of respective regression coefficients.

between consecutive latex vessels (AD) and nursery yield (Y) jointly or average distance between consecutive latex vessels (AD) singly were able to account for 56 and 39%, respectively, of LV variation. Inclusion of density of latex vessels (DV) as an independent variable together Y and AD did not significantly improve the predictive power. An increase of about 1% in the coefficient of determination was observed, suggesting that Y is not important in determining the LV in three-year old plants.

In accordance with the several high correlations that have been demonstrated between LV and Y in mature trees (Frey-Wyssling, 1930; Riches and Gooding, 1952, Naranayan and Ho, 1973), the

Table V - Stepwise multiple regression of girth at nursery stage (G) on nursery yield (Y), bark thickness (BT), total number of latex vessels rings (LV), overall density of latex vessels per five millimeters of bark (DV), average diameter of latex vessels (DL), average distance between consecutive latex vessels (AD) of bark samples taken from 30 three-year old *Hevea* seedlings.

Equation	Dependent variable	Independent variable	Intercept	R^2
4	G	2.7157** BT	16.0669	0.4143
		(0.6101)		
		2.9826** BT - 0.0517^{ns} DV	17.9586	0.4394
		(0.6547) (0.0471)		
		2.9839** BT - 0.0506^{ns} DV + 0.0062^{ns} AD	16.2578	0.4488
		(0.6615) (0.0476) (0.0094)		
		2.9722** BT - 0.0665^{ns} DV + 0.0068^{ns} AD + 0.4556^{ns} Y	15.9706	0.4529
		(0.6727) (0.0609) (0.0096) (1.0624)		
		3.0267** BT - 0.0748^{ns} DV + 0.0056^{ns} AD + 0.65174^{ns} Y - 0.0817^{ns} DL	17.6830	0.4580
		(0.6927) (0.0642) (0.0101) (1.1543) (0.1707)		
5	G	2.7157** BT	16.0669	0.4143
		(0.6101)		
		2.7448** BT - 1.6910^{ns} LV	22.8064	0.4463
		(0.6046) (1.3553)		
		2.9141** BT - 1.3044^{ns} LV - 0.0341^{ns} DV	22.5122	0.4555
		(0.6621) (1.4884) (0.0514)		
		2.9411** BT - 1.2013^{ns} LV - 0.0359^{ns} DV - 0.0295^{ns} DL	22.6789	0.4562
		(0.6906) (1.6172) (0.0533) (0.1607)		
		2.9479** BT - 1.0638^{ns} LV - 0.0376^{ns} DV + 0.0286^{ns} DL + 0.0013^{ns} AD	21.8217	0.4564
		(0.7078) (2.1344) (0.0567) (0.1643) (0.0130)		
6	G	2.7157** BT	16.0664	0.4143
		(0.6101)		
		2.7448** BT - 1.6910* LV	22.8064	0.4463
		(0.6046) (1.3553)		
		2.9141** BT - 1.3044* LV + 0.0341^{ns} DV	22.5122	0.4555
		(0.6621) (1.4885) (0.0514)		
		2.9411** BT - 1.2013* LV + 0.0359^{ns} DV - 0.0295^{ns} DL	22.6789	0.4562
		(0.6906) (1.6172) (0.0533) (0.1607)		
		2.9479** BT - 1.0638^{ns} LV + 0.0376^{ns} DV - 0.0286^{ns} DL + 0.0013^{ns} AD	21.8217	0.4565
		(0.7078) (2.1344) (0.0567) (0.1643) (0.0130)		

R^2 = Coefficient of determination.
* = $P < 0.05$.
** = $P < 0.01$.
ns = not significant.
Figures within brackets are the standard error of respective regression coefficients.

significant and positive correlation (r = 0.48327) between Y and LV obtained in this paper gives some indication that LV may be usefully used as a culling criterion. However this finding has to be treated with caution because of the following limitations. First, the seedlings used for this study were not selected at random and the sample size was small. Second, the locations where bark samples were collected in the seedling stem were not especially designed for this study, thus the height and the number of samples may not be sufficiently precise. Hence, this study should only be considered as preliminary. Further work using

Table VI - Stepwise multiple regression of total number of latex vessels rings (LV), on girth at nursery stage (G), bark thickness (BT), nursery yield (Y) overall density of latex vessels per five millimeters of bark (DV), average diameter of latex vessels (DL), average distance between consecutive latex vessels (AD) of bark samples taken from 30 three-years old *Hevea* seedlings.

Equation	Dependent variable	Independent variable	Intercept	R^2
7	LV	-0.0043** AD	5.1723	0.3928
		(0.0010)		
		-0.0039** AD + 0.2376** Y	4.4913	0.5597
		(0.0009) (0.0743)		
		-0.0040** AD + 0.1795^{ns} Y + 0.0050^{ns} DV	4.3530	0.5739
		(0.0009) (0.0971) (0.0054)		
		-0.0040** AD + 0.1732^{ns} Y + 0.0064^{ns} DV - 0.0580^{ns} BT	4.5111	0.5885
		(0.0009) (0.0974) (0.0056) (0.0617)		
		0.0038** AD - 0.1608^{ns} Y + 0.0074^{ns} DV - 0.0648^{ns} BT + 0.0094^{ns} DL	4.3151	0.5946
		(0.0009) (0.1056) (0.0059) (0.0633) (0.0156)		
8	LV	-0.0043** AD	5.1723	0.3928
		(0.0010)		
		-0.0042** AD + 0.0114* DV	4.4788	0.5180
		(0.0009) (0.0043)		
		-0.0039** AD + 0.0113* DV + 0.0152^{ns} DL	4.1059	0.5368
		(0.0009) (0.0043) (0.0418)		
		-0.0038** AD + 0.0118* DV + 0.0163^{ns} DL - 0.0150^{ns} G	4.4493	0.5567
		(0.0009) (0.0043) (0.0148) (0.0142)		
		-0.0038** AD + 0.0126** DV + 0.0173^{ns} DL - 0.0096^{ns} G - 0.0372^{ns} BT	4.3936	0.5600
		(0.0010) (0.0048) (0.0152) (0.0193) (0.0881)		
9	LV	-0.0043** AD	5.1723	0.3928
		(0.0010)		
		-0.0039** AD + 0.2376** Y	4.4913	0.5597
		(0.0009) (0.0743)		
		-0.0038** AD + 0.2492** Y - 0.0162^{ns} G	4.8844	0.5827
		(0.0009) (0.0743) (0.0136)		
		-0.0038** AD + 0.1901^{ns} Y - 0.0164^{ns} G + 0.0053^{ns} DV	4.7482	0.5974
		(0.0009) (0.0967) (0.0136)		
		-0.0039** AD + 0.1896^{ns} Y - 0.0140^{ns} G + 0.0055^{ns} DV + 0.0164^{ns} BT	4.7346	0.5981
		(0.0009) (0.0986) (0.0185) (0.0058) (0.0830)		

R^2 = Coefficient of determination.
* P < 0.05.
** P < 0.01.
ns = not significant.
Figures within brackets are the standard error of respective regression coefficients.

random and larger samples would be necessary to confirm the above findings.

For selection purposes it is useful to correlate nursery characters with yield of mature trees. There are few attempts reported in the literature relating nursery characters with future yield of mature trees. Narayanan *et al.* (1974) studied the relationship between yield of 33 month-old clones after budding, with yield obtained 56 months after budding and related the characters of the laticiferous system of the bark. G and LV were two structural properties important for determining yield of young plants in the nursery.

Laticiferous system as selection criteria

The significant correlation between LV and Y (r = 0.48327) or DV (r = 0.64168) gives an indication that the laticiferous system in young plants is useful for selection. Narayanan and Ho (1973), Narayanan *et al.* (1974) and Gonçalves *et al.* (1984) reported significant correlations between Y and some characters of the laticiferous system in juvenile and adult clones. These findings partially agree with the values of the present work obtained with three-year old ortets.

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RESUMO

Com o objetivo de identificar parâmetros de seleção precoce trinta plântulas de *Hevea brasiliensis* (Willd. ex. Adr. de Juss.) Müell. Arg. com diferentes níveis de produção foram avaliadas para vigor (G), produção (Y) e caracteres estruturais da casca. Os caracteres foram: espessura de casca (BT), número total de anéis de vasos laticíferos (LV), densidade dos vasos em 5 mm do anel (DV), diâmetro médio dos vasos laticíferos dos anéis (DL) e distância média entre os consecutivos anéis de vasos laticíferos (AD). Os resultados mostraram correlações não significativas negativas entre Y e G ou DL ou AD. Nenhuma correlação foi detectada entre Y e LV ou DV. As correlações entre BT e G ou BT e AB foram positivas e significativas. Estudos de regressão múltipla de Y com DV, LV, DL, BT e G sugerem que DV e LV embora não significativos foram as variáveis que contribuíram para mais de 18% da variação em Y. Quando G foi utilizada como variável dependente, com Y, BT e DV, BT foi a mais importante e significativa variável contribuindo com 58% da variação em G. Estudos de LV com BT, DL ou Y mostram que BT foi a variável mais dominante e significativa contribuindo com 14% da variação em LV. A produção não contribui de forma significativa e positiva para LV.

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