

## RELATION BETWEEN GROWTH HABIT AND YIELD IN *HEVEA* CULTIVARS IN NORTH SUMATRA

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The BPPM began breeding of *Hevea brasiliensis* as early as 1920 by hand pollination up to 1941 and continued during the years 1958 to 1962 and 1967 to 1970. Pollinations made after 1958 used the latest recommended clones at the time of pollination e.g. AVROS 337, 427, 1734, 1917, 2037, TT 5, GT 1, PR 107. These clones have been recommended for small to large scale planting by BPP Medan. Several clones have also been planted in other countries as a result of the international exchange of clones in 1954, and the yield and some other characteristics are known at present.

Study of the relation between growth habit and yield characters may be useful to shorten the period of selection. Based on observations in North Sumatra some of the interrelation between these characters will be dealt at some length below.

The low yield of the "slow starter" clones during the early years of maturity is less profitable so it is desirable to raise the initial yield of these slow starters by breeding. Hand pollinations made during 1955—1961 included "slow starter" clones e.g. AVROS 2037 and PR 107 and "quick starter" clones e.g. AVROS 427 and AVROS 1734. Study of the progeny obtained from such pollinations could be useful in the search for new clones having the desired yield trend, and for selection of parents for further breeding programmes.

Subramaniam (1972) discussed work carried out at the RRIM on investigation of inheritance of yield and girth in *Hevea*. These studies have indicated that additive combining abilities predominate in the variance of yield and girth. He stated that family prediction and phenotypic selection are effective in *Hevea* breeding.

### NOTES ON CERTAIN CLONES IN NORTH SUMATRA

Information on the performance of certain clones and their characteristics have been reported by Napitupulu (1971) and Napitupulu *et al.*, (1972).

AVROS 337 is of average vigour and shows average increment on tapping; the clone has a straight stem and rough virgin bark, its yield is below that of PR 107 or GT 1.

AVROS 427 and AVROS 1734 have high initial yields, but yield declines when tapped on virgin bark using S/2, d/2, 100% tapping system. Both clones have a poor and below average, relatively low girth increment especially in the case of AVROS 427, and they are susceptible to wind damage. The bark renewal of AVROS 1734 is very good. Both clones have many light horizontal branches.

AVROS 1191 and AVROS 1917 are other high yielding clones with poor habit and are very susceptible to wind damage, especially AVROS 1191. Both clones exhibit a high initial yield with falling trend. Branching habit of these two clones is different; both AVROS 1191 and AVROS 1917 have light to moderate long branches (with a fan-shaped crown).

AVROS 2037 has a low yield during the first two years of tapping, but afterwards the yield becomes high. It is very vigorous clone, with little wind damage, although some bending with mature trees may occur. The response to Ethrel stimulation seems to be promising. The habit is characterised by the formation of two or three heavy long branches and a rise at a wide angle, with a fan-shaped crown. This clone is recommended for commercial large scale planting by BPPM.

PR 107 yields poorly on the first panel but afterwards it has a rising yield trend, average vigour and girth increment, strong branching habit similar to fork type.

GT 1 has a higher yield than PR 107 on the first panel, and afterwards shows a rising yield trend. The habit is very attractive with average vigour and girth increment. Both clones are recommended for commercial large scale planting by BPPM.

TT 5 has an average girth and a straight stem: its yield is below that of AVROS 2037.

TABLE 1 shows the yield in g/tree/tapping of some above mentioned clones as obtained in two trials.

Observation on various clones has shown that girth increment on tapping has a relation with the yield trend; good increment causes a rising yield trend.

As the wind is blowing fast in North Sumatra, much attention is paid to wind resistance. Most of the Sumatra clones have a fan-shaped crown; some of these clones are susceptible to wind damage but others are less susceptible. Cone-shaped crowns also show different susceptibilities to wind damage. Crowns that are unproportionally large or located too high on the stem may be easily damaged by wind. Many of the susceptible clones have a heavy crown during the latter immature or early mature period e.g. AVROS 427, R 1017, RRIM 605, PR 226.

A sharp angle between the branches and stem axis typifies a weak branch, while a fork or candle light type usually indicates a strong branch. According to Wycherley (1969) cone shaped trees have a good assimilation apparatus and are less susceptible to wind damage.

#### RELATION BETWEEN GIRTH AND YIELD

Individual tree yield and girth data for clone AVROS 2037, GT 1, PR 107, seedling mother trees and that of the clones derived from them have been studied in certain clone and seedling trials. The correlation of girth and yield per trees within clones has been studied in AVROS 2037 in experiment K 103 (1957), in GT 1 in K 148 (1960) and in PR 107 in K 150 (1962).

TABLE 2 summarises the means, standard deviation, coefficients of variability, correlation coefficients and linear regression equations for these five groups of data.

For the three clones, variability of girth is rather high, due to the chequered history of these fields. The variability of yield of AVROS 2037 is quite low. In each clone, the correlation between girth and yield is around 0.66. The linear regressions show that the increase of yield with girth is much steeper for GT 1 and PR 107 than for AVROS 2037.

Difference between clones in slope of the girth-yield regression have been reported by various workers (Paardekooper, 1954; Narayanan & Ho Chai Yee, 1970). The former author has shown that when the relationship is expressed as a curvilinear regression, of the form  $\text{yield} = K \text{girth}^m$ ,  $m$  varies between clones and age from around 1.5 to 3. On the average, the relationship is quadratic ( $m=2$ ); this implies that an increase in girth of 10% will correspond to an increase in yield of around 20%. Of the data under review, those of GT 1 suggest curvilinearity, with  $m = 1.5$ . Narayanan & Ho Chai Yee (1970) confirmed the differences in steepness of the regression yield on girth between clones, and also reported that this slope tends to increase with age.

In the group of 92 seedlings, variability of girth and in particular of yields are, as expected, considerably higher than for the buddings. The correlation between girth and yield is low but significant (% 0.274).

In the group of 92 clones derived from the above seedlings (mean over 6-12 trees), the variability in girth and yield between the clones is much lower than for the seedlings; this is because part of the non-genetical variation has been removed by averaging over a number of trees. There is no correlation between girth and yield; this is probably because part of the girth-yield correlation between clones is environmental, and averaging over a number of buddings has removed this correlation. One would expect even between clones the yield to depend to some extent on the girth, and in clone trials low but positive correlations have often been found. Wycherley (1969) states that in the first year of tapping, girth and yield between clones are positively correlated, but as tapping proceeds this correlation disappears and may even become negative.

The data on the 92 hand pollinated seedlings and the clone derived thereof have also been used to study the relation between mother-tree and its derived clone. Results are summarised in TABLE 3. For girth the correlation is 0.40, for yield 0.60. These correlations are somewhat higher than usually found; they may partly be caused by environmental factors, because the mother-tree seedlings were planted together with further derived buddings in the same plot.

Results of similar studies were reported by Paardekooper (1954); Wycherley (1969).

While in the past the correlation between mother-tree and derived clones was often considered too low to make mother-tree selection an efficient method, recently mother-tree selection (based on girth and yield of mature trees) has been recognised again as a useful tool in selection; the number of hand pollinations should also be taken into consideration. The present studies confirm this view.

#### *Yield and Girth of Seedlings Obtained from 1955-1958 Hand Pollination Programmes*

The planting material obtained from hand pollination during 1955-1958 has been tested in a legitimate seedling trial at the BPPM Experimental Station Aek Panour. As the hand pollinations were limited in number and available data are still incomplete,

only the data on girth at 6 and 11 years of certain crossing and the mean yield during 8-11 year have been analysed. Yields were expressed in g/tree/tapping, based on actual tapped trees, not taking dry trees into account. Seedlings were compared in order to assess the value of the parent clones when used in various combinations.

Clones AVROS 337, 427, 1191, 1734, 1917, 2037, TT 5, GT 1 and PR 107 are the parents used. The mean yield during 3 to 6 years of tapping in g/tree/tapping and mean girth at 6 and 11 years old are given in Table 4.

Since not all possible combination between the nine parent clones are available, the combination of parents has been grouped into two groups :

- a : AVROS 337, 427, 1917, 2037 and TT 5
- b : AVROS 337, 1191, 2037, TT 5 and PR 107.

In each group the general combining ability effects according to Griffing (1956) were calculated for girth and yield.

Table 4, showed that AVROS 427, 1191 and 1917 seedlings were the highest yielders during the observation, followed by AVROS 2037 seedlings, but girth was relatively poor for AVROS 427, 1191, 1917 seedlings (both immature and mature trees). AVROS 427, 1191 and 1917 are known as "quick starter" clones with poor girth increment. AVROS 2037 is a "slow starter" with good girth increment and very vigorous habit.

Between the families there appear to be a negative relation between yield and girth, Roos & Brookson (1966) have found significant positive correlation between yield and girth over fifteen years of tapping.

The highest yielding family with good vigour were AVROS 427 x AVROS 2037 and AVROS 1734 x AVROS 2037. Other families with high yield but poor growth were AVROS 1917 x AVROS 337; AVROS 1917 x AVROS 2037; AVROS 1191 x AVROS 2037; AVROS 1191 x PR 107. Note that here is a half sibs relationship between the parents of clone AVROS 1191, 1917 and AVROS 2037. The families AVROS 1191 x AVROS 2037 and AVROS 1917 x AVROS 2037 show some inbreeding effect for girth; but not for yield during the observation.

Estimates of the general and specific combining ability effects are shown in Tables 5a, 5b, 6a and 6b.

#### CONCLUSIONS

The conclusion that may be drawn from these studies were as follows :

1. A very heavy canopy at the early mature period shows more susceptibility to wind damage. Wide angle branchers of candle light type are more resistant to wind damage. But further investigation is still needed on the effect of habit.
2. There is a positive correlation between individual yield and girth within clones but not between clones.
3. Increase of yield corresponding with increase in girth is highest for PR 107 and is followed by GT 1 and AVROS 2037, respectively.
4. Breeding vigorous trees to reduce the unproductive period may be useful.

TABLE 1  
YIELD OF SELECTED CLONES IN CLONE TRIAL  
E 11 AND E 12

Clone/Trial	Yield (g/tree/tapping)							Mean yield over 7 yrs
	1st yr	2nd yr	3rd yr	4th yr	5th yr	6th yr	7th yr	
<b>Trial E 11</b>								
AVROS 1191	11.1	18.8	27.5	46.2	46.8	48.9	46.6	35.1
AVROS 1917	10.2	12.0	19.2	32.7	45.2	56.5	64.5	34.3
AVROS 2037	8.7	8.6	17.9	32.9	40.0	50.1	54.3	30.4
PR 107	10.4	12.9	16.4	25.6	23.6	21.1	23.6	19.1
<b>Trial E 12</b>								
AVROS 427	25.6	22.5	24.3	29.7	58.5	41.2	41.4	34.7
AVROS 1734	23.1	25.2	25.0	28.6	45.0	45.0	43.8	33.7
GT 1	17.2	19.1	18.8	22.9	40.7	39.6	38.9	28.2
PR 107	14.3	15.1	18.0	19.1	29.9	31.8	32.8	23.0

TABLE 2  
THE RELATIONSHIP BETWEEN GIRTH (X) AND YIELD (Y) FOR DIFFERENT CLONES AND SEEDLINGS

Clone/Seedling	Number of observations (n)	Years old	Girth (cm)			Yield/g/tree/tapping			Linear correlation and regression	
			Mean (x)	S. D.	C.V.%	Mean (y)	S. D.	C.V.%	r	$y = bx + a$
(a) Avros 2037	83	11	89.2	13.0	14.6	46.4	9.3	20.0	0.665***	$0.475x + 4.05$
(b) GT 1	63	11	84.9	12.6	14.8	46.9	14.2	30.4	0.656***	$0.743x - 15.97$
(c) PR 107	100	9	74.4	9.4	12.7	45.4	13.4	29.6	0.678***	$0.970x - 26.76$
(d) Mother tree seedling	92	9	85.2	13.8	16.2	40.4	16.9	41.9	0.274**	$0.337x + 11.70$
(e) Clones derived from above m. t. s.	92*	9	77.2	7.6	9.3	41.5	12.1	29.1	-0.028NS	$0.045x - 44.98$

(\*\*\* P 0.001 \*\* P 0.01 N.S.—Not significant.) 92\* clone means each clone 6-12 trees.

TABLE 3

GIRTH AND YIELD RELATIONSHIP BETWEEN SEEDLINGS AND THAT OF THEIR DERIVED CLONES.

r	$y' = bx' + a$	$x_1 =$ girth of seedling
0.399***	$x_2 = 0.260 x_1 + 59.73$	$x_2 =$ girth of their derived clones
0.604***	$Y_2 = 0.431 Y_1 + 24.10$	$Y_1 =$ yield of seedling $Y_2 =$ yield of their derived clones

TABLE 4a  
MEAN YIELD AND GIRTH FOR EACH CROSS AND RECIPROCAL  
IN GROUP AVROS 337, 427, 1917, 2037 AND TT 5

Parent clone	Variable	Parent clone					Zi	Mean
		AVROS 427	AVROS 1917	AVROS 2037	TT5			
AVROS 337	y	42.1	43.7	41.8	35.0	162.6	40.7	
	x1	53.5	58.8	63.3	61.0	236.6	59.2	
	x2	89.6 (34)	89.4 (182)	97.0 (154)	94.0 (71)	370.0	92.5	
AVROS 427	y		47.5	44.9	38.6	173.1	43.3	
	x1		59.7	59.7	60.5	233.4	58.4	
	x2		93.6 (84)	96.9 (85)	91.9 (48)	372.0	93.0	
AVROS 1917	y			43.0	40.0	174.2	43.6	
	x1			54.0	62.0	234.5	58.6	
	x2			88.3 (174)	101.0 (26)	372.3	93.1	
AVROS 2037	y				40.8	170.5	42.6	
	x1				65.0	242.0	60.5	
	x2				99.5 (86)	381.7	95.4	
TT 5	y					154.4	38.6	
	x1					248.5	62.1	
	x2					386.4	96.6	

$$Zy = 417.4$$

$$Zx1 = 597.5$$

$$Zx2 = 941.2$$

TABLE 4b  
MEAN YIELD AND GIRTH FOR EACH CROSS AND RECIPROCAL  
IN GROUP AVROS 337, 1191, 2037, TT 5 AND PR 107

Parent clone	Variable	Parent clone				Zi	Mean
		AVROS 1191	AVROS 2037	TT 5	PR 107		
AVROS 337	y	42.3	41.8	35.0	35.7	154.8	38.7
	x1	58.5	63.3	61.0	59.0	241.8	60.5
	x2	94.5 (121)	97.0 (154)	97.0 (71)	91.9 (160)	377.4	94.4
AVROS 1191	y		45.3	38.5	48.5	174.6	43.7
	x1		36.0	60.0	56.0	210.5	52.6
	x2		55.0 (6)	96.7 (154)	79.0 (11)	325.2	81.3
AVROS 2037	y			40.8	33.6	161.5	40.4
	x1			65.0	66.2	230.5	57.6
	x2			99.5 (86)	107.3 (145)	358.8	89.7
TT 5	y				39.3	153.6	38.4
	x1				53.4	239.4	59.9
	x2				99.2 (180)	389.4	97.4
PR 107	y					157.1	39.3
	x1					234.6	58.7
	x2					377.4	94.4

$$Zy = 400.8$$

$$Zx1 = 578.4$$

$$Zx2 = 914.1$$

TABLE 4C  
MEAN YIELD AND GIRTH FOR EACH CROSS AND RECIPROCAL

Parent clone	Variable	Parent clone							
		AVROS 337	AVROS 427	AVROS 1191	AVROS 1917	AVROS 2037	TT 5	PR 107	Mean
GT 1	y	35.8	43.6	43.8	47.1	37.6	—	36.1	40.7
	x1	59.0	60.0	59.9	53.1	53.0	—	57.0	57.0
	x2	89.0 (22)	77.0 (46)	86.0 (62)	80.0 (28)	79.9 (38)	—	82.0 (97)	82.3
AVROS 1734	y	—	—	52.6	—	43.7	38.2	—	44.8
	x1	—	—	49.0	—	61.0	64.0	—	58.0
	x2	—	—	88.0 (21)	—	98.0 (20)	94.0 (67)	—	93.3

NOTE: Table 4a, b, c, :

y : mean yield during 3rd—6th yr in g/tree/tapping

x1 : mean girth of 6 yr old (cm)

x2 : mean girth of 11 yr old (cm)

(...) : figures within brackets denote number of trees

— : no crossing

TABLE 5a  
MEAN YIELD, GIRTH OF SEEDLINGS AND G.C.A. IN  
GROUP AVROS 337, 427, 1917, 2037 AND TT 5.

Parent	Yield of seedlings g/tree/tapping (Y)	Girth of seedling in cm		General combining ability (g. c. a.)		
		6th yr (x1)	11th yr (x2)	y	x1	x2
AVROS 337	40.7	59.2	92.5	-1.45	-0.8	-2.2
AVROS 427	43.3	58.4	93.0	2.05	-1.8	-1.5
AVROS 1917	43.6	58.6	93.1	2.41	-1.5	-1.4
AVROS 2037	42.6	60.5	95.4	1.18	1.0	1.7
TT 5	38.6	62.1	96.6	-4.19	3.2	3.3

TABLE 5b  
MEAN YIELD, GIRTH OF SEEDLINGS AND G.C.A. IN  
GROUP AVROS 337, 1191, 2037, TT 5 AND PR 107

Parent	Yield of seedlings g/tree/tapping (Y)	Girth of seedling in cm		General combining ability (g. c. a.)		
		6th yr (x1)	11th yr (x2)	y	x1	x2
AVROS 337	38.7	60.5	94.4	-1.84	3.5	3.9
AVROS 1191	43.7	52.6	81.3	4.76	-6.9	-13.5
AVROS 2037	40.4	57.6	89.7	0.39	-0.3	2.3
TT 5	38.4	59.9	97.4	-2.24	2.7	7.9
PR 107	39.3	58.7	94.4	-1.07	1.1	3.9

y : g.c.a. for yield (during 3rd—6th yr tapping)  
x1 : g.c.a. for girth (6 yrs old)  
x2 : g.c.a. for girth (11 yrs old)

TABLE 6a  
SPECIFIC COMBINING ABILITY (S.C.A.) OF EACH FAMILY IN  
GROUP AVROS 337, 427, 1917, 2037, TT 5

Parent	s.c.a.	AVROS 427	AVROS 1917	AVROS 2037	TT5
AVROS 337	y	-0.2	-1.0	0.4	-1.1
	x1	-3.6	1.4	3.4	-1.1
	x2	1.3	-1.8	2.6	-1.9
AVROS 427	y		1.3	0.0	-1.0
	x1		3.4	0.8	-0.5
	x2		4.6	4.7	-1.8
AVROS 1917	y			-2.3	0.1
	x1			-5.2	0.6
	x2			-6.8	4.3
AVROS 2037	y				2.1
	x1				1.1
	x2				-0.3

TABLE 6b  
SPECIFIC COMBINING ABILITY (S.C.A.) OF EACH FAMILY IN  
GROUP AVROS 337, 1191, 2037, TT 5, PR 107

Parent	s.c.a.	AVROS 1191	AVROS 2037	TT5	PR 107
AVROS 337	y	-0.7	-3.2	-1.0	-1.4
	x1	4.1	2.3	-3.0	-3.4
	x2	12.7	4.0	-9.2	-7.3
AVROS 1191	y		0.1	-4.1	4.7
	x1		-14.6	1.4	4.0
	x2		-20.6	10.9	-2.8
AVROS 2037	y			2.6	-5.8
	x1			4.8	7.1
	x2			2.5	14.3
TT 5	y				2.5
	x1				-8.2
	x2				-4.0

NOTE: Table 6a, b : y — s.c.a. for yield (during 3rd—6th yr tapping)  
x1 — s.c.a. for girth (6 yr old)  
x2 — s.c.a. for girth (11 yr old)

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