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Tapping and Partition

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The partition of assimilates between rubber and accumulation of dry matter is estimated in tapping experiments by means of an equation relating shoot dry weight to girth. There is evidence that competition between trees allocated to different treatments may introduce bias after the first year of tapping in 'single-tree-plot' experiments as a result of differential growth. Within clones and years of tapping the 'shoot loss' (reduction in dry weight accumulation) is proportionate to the yield of rubber. Tapping itself, irrespective of the yield, causes some reduction in growth. Shoot loss tends to be greater than that calculated from the calorific equivalent of the yield of rubber under conditions of long flow of latex, whether the latter is due to tapping system, application of stimulants or to low plugging as a clonal characteristic. The intensity of the adverse partition declines with age.

The possible cause of this adverse partition associated with long flow is discussed in relation to its significance in trunk-snap, the reorientation of the selection of bred cultivars and of crowns for top-working, and their integration with modern methods of exploitation throughout the economic life of the trees. The early introduction of bias due to competition may necessitate review of experimental procedures.

The partition of assimilates between increment in dry weight and yield of rubber was estimated in two studies by TEMPLETON (1969a, b). In the former, trees of six clones were sampled for dry weight determinations prior to opening half the trees of each clone for tapping. After two years, tapped and untapped trees of each clone were sampled. The mean yields were determined from the whole tapped stand of each clone, instead of being recorded from the individual trees subsequently weighed. The population used to estimate dry weight increment during tapping was not the same as, but only a small part of, that for yield. This probably caused some anomalies observed.

The untapped trees accumulated greater dry weights than the tapped trees, the difference was termed the 'shoot loss' (*i.e.* growth not made) by the tapped trees. The increment in dry weight of the untapped trees ranged from 59.5 kg to 112.2 kg, the shoot loss of the tapped trees from 2.3 kg to 45.5 kg and their yields from 3.09 kg to 4.78 kg per two years. The ratio of rubber-shoot loss ranged from 10% to 192% and the ratio of rubber-dry weight increment of the tapped trees (c.f. Niciporovic's coefficient of effectiveness) varied from 3.0% to 11.1%.

The formula of SHORROCKS *et al.* (1965) was used by TEMPLETON (1969b) to estimate the dry weights of the shoots of the trees in various clonal trials during the second year of tapping. The yields were recorded from approximately the same populations of trees. Untapped trees were not available for comparison. The total dry weight production ranged from 18.6 kg to 63.4 kg and the yields from 1.63 kg to 9.12 kilogram. The partition ratio was calculated as the weight of rubber × 2.5 (for its higher calorific value) divided by the total dry weight production (dry weight increment + rubber); it ranged from 7.1% to 52.3%.

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Some trees left untapped in a thirty-three-year-old stand of Tjir I had total dry weights more than twice those of the tapped trees, 4592 kg *versus* 2119 kg (SHORROCKS, 1965). Estimates of the dry weight prior to opening were not readily available. If the cumulative yield was about 140 kg per tree, the ratio of rubber-tree loss was perhaps 6%, the ratio of rubber – dry weight increment of tapped trees 7% and the partition ratio 13%. These uncertainties aside, the untapped trees were in the same – not a separate – stand as the tapped trees, the former eventually overgrew the latter and had a competitive advantage introducing bias.

The examples quoted indicate that in general the accumulation of dry matter is depressed by the extraction of rubber. This study investigates the relationship between the shoot loss and the yield especially with respect to tapping system.

MATERIALS AND METHODS

The formula of SHORROCKS *et al.* (1965) was used to estimate dry weights. The average dry weight of each population of trees was estimated from their mean girth. This has probably caused an under-estimate in the mean dry weight of about 5% compared with calculating this as the mean of the individual dry weights estimated from the individual tree girths (WYCHERLEY, 1971).

The regression equation of SHORROCKS *et al.* (1965) enabled calculation of the shoot dry weight to within 15% of the observed value for individual trees of up to 60 cm in girth, but the error was larger for trees of greater girth. For groups of trees or treatment means the probable error is estimated as $15/\sqrt{n}\%$ of the mean for trees of less than 60 cm girth and as $27/\sqrt{n}\%$ for larger trees, where n is the number of trees. In the tapping experiments n was 48 or more and in the clone trial n was 100 or more; therefore the probable errors were respectively in the ranges 2% to 4% and 1.5% to 2.7% and acceptable for the purposes of this investigation, especially as successive measurements were made on the same population of trees.

The data, namely girth, yield, percentage of late drip in the total crop and dry rubber content (d.r.c.) of the latex harvested, were obtained (except for those concerning Fields 48AD in *Table 17*) from the series of tapping experiments reported by NG *et al.* (1965), NG *et al.* (1969), NG, *et al.* (1970) and in RUBBER RESEARCH INSTITUTE OF MALAYA (1966, 1967, 1968, 1969a, 1970a). The data for the unstimulated treatments only were used. The nomenclature of the experiments concerning Panels A and B and the Estates I, II, etc. follows that in the references cited.

The mean shoot dry weight of the trees in each treatment was estimated from the mean girth. The increments in dry weight were calculated from the differences in estimated dry weight at the beginning and end of the year of tapping. The relative growth rates (corresponding to the rate of compound interest) were calculated from the differences between the natural logarithms of the estimated shoot dry weights (dividde by the period in years, one year in all cases considered here) after BLACKMAN (1919).

The RRIM 600 series clonal trials in Fields 48AD of the RRIM Experiment Station, Sungei Buloh, have been reported in numerous publications from the RUBBER RESEARCH INSTITUTE OF MALAYA (1957, 1958) onward. The data for this investigation were collated specially by HO (1971) and consisted of those for girth, yield and losses through storm-damage during the first five years of tapping, and the clonal plugging indices (MILFORD *et al.*, 1969). Shoot dry weight was estimated from girth as described.

The correlations between the variables in the tapping experiments were analysed by their simple linear regressions. The data in the clonal trial were analysed by multiple regressions.

RESULTS

The estimated annual increments in dry weight and the relative growth rates of the trees untapped for up to three years in the Panel A experiments are given in *Table 1*. The range in increments is from 38.6 kg to 112.8 kg per tree per year. Cases of increments rising and falling with time are roughly evenly represented. The relative growth rate (approximately increment per mean total weight) declines with age except in four out of thirty-two cases. The range is from 0.138 kg to 0.452 kg/kg per year.

The mean yield, increase in dry weight, relative growth rate, percentage late drip of the crop and percentage dry rubber content of the latex harvested and the correlation coefficients between yield and the last two variables are given for the tapped trees by experiments (clones and estates) and years of tapping in *Tables 2, 3* and *4*. The data, corresponding to those given in *Table 1* for the trees which remained untapped for up to three years in the Panel A experiments, are given for the tapped trees in *Tables 2* and *3*. There were no untapped trees in the Panel B experiments *(Table 4)*.

The increments in dry weight for trees tapped on Panel A *(Tables 2* and *3)* range from 15.6 kg to 53.1 kg per tree per year and the corresponding relative growth rates from 0.088 kg to 0.238 kg/kg per year. There is no clear trend in either increments or relative growth rates with successive years of tapping (those in *Table 2* cover a longer period than the corresponding figures in *Table 1*). The percentage late drip usually declines markedly in the later years of tapping Panel A. Changes in the mean dry rubber content are inconsistent and relatively small. The correlations between

TABLE 1. ESTIMATED INCREMENTS IN DRY WEIGHT AND RELATIVE GROWTH RATES OF UNTAPPED TREES (PANEL A EXPERIMENTS)

Clone	Estate	Increments in dry weight (kg)			Relative growth rate (kg/kg/year)		
		First year	Second year	Third year	First year	Second year	Third year
GT 1	I	112.8	111.8	105.1	0.452	0.308	0.222
RRIM 605	I	80.0	85.9	91.7	0.349	0.275	0.228
RRIM 623	I	99.5	94.2	109.4	0.342	0.243	0.223
GT 1	II	72.3	69.5	69.6	0.369	0.260	0.206
PB 5/51	II	56.8	44.2	54.6	0.298	0.183	0.188
PB 5/63	II	56.2	29.9	49.4	0.324	0.138	0.192
RRIM 513	II	61.4	65.8	53.5	0.324	0.261	0.170
RRIM 600	II	55.5	69.5	95.6	0.309	0.287	0.296
RRIM 605	II	57.0	49.9	74.1	0.329	0.220	0.257
RRIM 607	II	64.2	71.6	63.8	0.324	0.269	0.191
RRIM 623	II	53.7	67.8	73.1	0.254	0.249	0.213
GT 1	VI	77.0	94.3	–	0.365	0.318	–
PB 5/51	VII	68.9	68.7	–	0.356	0.261	–
PB 28/59	VII	63.3	78.0	–	0.318	0.288	–
PB 28/59	VIII	58.3	38.6	–	0.282	0.157	–
RRIM 600	VI	67.6	70.0	–	0.360	0.272	–
RRIM 605	VI	64.1	76.8	–	0.355	0.307	–
RRIM 607	V	72.6	65.6	–	0.331	0.226	–
RRIM 623	VII	70.0	68.4	–	0.294	0.221	–
RRIM 628	VII	62.6	64.6	–	0.298	0.236	–
RRIM 628	VIII	52.0	38.6	–	0·297	0.175	–
RRIM 701	VII	97.6	–	–	0.408	–	–

TABLE 2. MEANS OF YIELD, ESTIMATED INCREASE IN DRY WEIGHT, RELATIVE GROWTH RATE, PERCENTAGE LATE DRIP, PERCENTAGE DRY RUBBER CONTENT AND CORRELATION COEFFICIENTS BETWEEN YIELD AND RESPECTIVELY LATE DRIP AND D.R.C. FOR TAPPED TREES ONLY (PANEL A EXPERIMENTS)

Clone	Estate	Year	Yield (kg)	Increased dry weight (kg)	Relative growth rate (kg/kg/year)	Late drip (%)	d.r.c. (%)	*r*: yield and late drip	*r*: yield and d.r.c.
GT 1	I	1	3.5	53.1	0.238	12.4	–	+0.706*	–
GT 1	I	2	4.2	53.1	0.190	18.5	34.7	+0.766**	−0.689*
GT 1	I	3	5.0	41.7	0.129	20.6	33.8	+0.078	+0.033
GT 1	I	4	5.0	41.8	0.115	17.6	32.3	−0.757*	+0.755*
GT 1	I	5	2.7	50.1	0.121	17.6	33.9	−0.795**	+0.430
RRIM 605	I	1	4.6	37.1	0.178	20.8	–	+0.244	–
RRIM 605	I	2	5.9	46.1	0.184	19.0	–	+0.334	–
RRIM 605	I	3	6.2	42.0	0.142	18.4	36.4	+0.089	−0.298
RRIM 605	I	4	6.4	43.8	0.129	15.8	38.3	−0.258	−0.235
RRIM 623	I	1	4.7	44.3	0.165	19.1	–	+0.011	–
RRIM 623	I	2	5.0	52.3	0.164	15.0	–	+0.345	–
RRIM 623	I	3	4.9	51.0	0.136	12.4	37.5	+0.556	−0.599
RRIM 623	I	4	4.9	52.3	0.131	12.0	38.5	−0.327	+0.332
GT 1	II	1	2.4	34.9	0.198	10.6	–	+0.637*	–
GT 1	II	2	2.8	34.3	0.160	7.3	36.3	+0.705*	−0.967***
GT 1	II	3	3.4	31.8	0.127	6.4	35.5	+0.814**	−0.957***
GT 1	II	4	3.1	34.2	0.122	4.8	35.1	+0.627	−0.788**
GT 1	II	5	4.0	54.5	0.167	5.6	34.8	+0.741*	−0.828**
PB 5/51	II	1	2.5	25.3	0.148	8.9	–	−0.206	–
PB 5/51	II	2	2.5	26.3	0.133	6.2	38.5	−0.446	+0.021
PB 5/51	II	3	2.8	21.6	0.097	4.8	38.1	−0.638*	+0.216
PB 5/51	II	4	2.1	21.7	0.089	3.5	39.6	−0.595	−0.196
PB 5/51	II	5	3.5	31.7	0.116	2.9	39.1	−0.702*	−0.168
PB 5/63	II	1	2.6	22.3	0.142	11.4	–	+0.050	–
PB 5/63	II	2	3.4	15.6	0.088	15.4	28.6	+0.065	+0.533
PB 5/63	II	3	4.2	26.7	0.136	21.0	29.5	−0.268	+0.660*
PB 5/63	II	4	3.7	23.7	0.106	20.4	29.6	−0.276	+0.465
PB 5/63	II	5	4.6	28.3	0.114	16.6	31.7	−0.046	+0.830**
RRIM 513	II	1	2.7	15.9	0.097	11.6	–	+0.031	–
RRIM 513	II	2	2.8	28.4	0.152	5.2	37.0	−0.051	−0.283
RRIM 513	II	3	3.6	20.8	0.098	3.7	36.7	+0.004	−0.482
RRIM 513	II	4	3.9	31.4	0.132	2.5	36.8	+0·285	−0.656*
RRIM 513	II	5	4.4	25.7	0.096	2.5	36.7	−0.424	−0.290
RRIM 600	II	1	2.9	31.3	0.192	17.7	–	+0.234	–
RRIM 600	II	2	4.0	44.4	0.219	19.7	34.8	+0.517	+0.031
RRIM 600	II	3	4.7	61.0	0.239	8.7	34.8	+0.325	−0.621
RRIM 600	II	4	4.6	43.6	0.141	4.0	35.9	+0.283	−0.505
RRIM 600	II	5	5.3	38.1	0.109	3.4	37.0	+0.185	−0.664*
RRIM 605	II	1	3.0	25.0	0.161	16.5	–	+0.364	–
RRIM 605	II	2	3.3	24.6	0.136	13.9	36.9	+0.376	+0.016
RRIM 605	II	3	3.7	32.9	0.157	9.1	36.4	+0.187	−0.481
RRIM 605	II	4	3.7	28.2	0.116	7.2	35.9	+0.263	−0.570
RRIM 605	II	5	4.5	22.7	0.084	5.5	36.2	+0.341	−0.410
RRIM 607	II	1	2.7	26.2	0.146	14.2	–	+0.775**	–
RRIM 607	II	2	3.2	35.4	0.168	10.4	36.7	+0.800**	−0.544
RRIM 607	II	3	3.3	29.4	0.120	8.8	36.5	+0.573	−0.540
RRIM 607	II	4	3.2	33.4	0.121	8.1	37.1	+0.369	−0.737*
RRIM 607	II	5	4.1	45.0	0.142	7.6	35.8	+0.330	−0.566
RRIM 623	II	1	2.5	23.5	0.122	8.5	–	+0.014	–
RRIM 623	II	2	3.0	30·8	0.139	11.0	36.3	+0.311	+0.235
RRIM 623	II	3	3.1	38.1	0.149	8.6	35.4	−0.422	+0.220
RRIM 623	II	4	3.1	39.8	0.134	6.7	35.6	−0.225	−0.267
RRIM 623	II	5	3.4	37.0	0.111	4.0	36.3	−0.203	−0.573

* P = <0.05   ** P = <0.01   *** P = <0.001

TABLE 3. MEANS OF YIELD, ESTIMATED INCREASE IN DRY WEIGHT, RELATIVE GROWTH RATE, PERCENTAGE LATE DRIP, PERCENTAGE DRY RUBBER CONTENT AND CORRELATION COEFFICIENTS BETWEEN YIELD AND RESPECTIVELY LATE DRIP AND D.R.C. (FURTHER PANEL A EXPERIMENTS)

Clone	Estate	Yea.	Yield (kg)	Increased dry weight (kg)	Relat ve growth rate (kg/kg/year)	Late drip (%)	d.r.c. (%)	*r*: yield and late drip	*r*: yield and d.r.c.
GT 1	VI	1	2.9	39.2	0.202	11.1	35.3	+0.653	−0.897***
GT 1	VI	2	4.7	39.9	0.171	16.0	35.3	+0.341	−0.839***
PB 5/51	VII	1	2.2	35.4	0.207	6.7	35.5	+0.782**	−0.836***
PB 5/51	VII	2	3.0	39.8	0.190	6.8	37.6	+0.496	−0.723**
PB 28/59	VII	1	3.1	27.3	0.154	19.7	38.1	+0.559*	−0.811***
PB 28/59	VII	2	6.3	27.4	0.134	19.9	35.5	+0.024	−0.295
PB 28/59	VIII	1	3.7	16.6	0.089	23.0	34.0	+0.464	−0.533
PB 28/59	VIII	2	5.0	21.4	0.106	14.5	38.9	+0.218	−0.106
RRIM 600	VI	1	3.1	34.6	0.206	22.5	29.8	+0.028	−0.701**
RRIM 600	VI	2	3.7	46·2	0.221	16.5	33.6	+0.684**	−0.766**
RRIM 605	VI	1	3.7	29.2	0.178	28.7	32.8	+0.515	−0.426
RRIM 605	VI	2	4.2	46.2	0.231	16.7	37.1	+0.572*	−0.831***
RRIM 607	V	1	3.1	30.7	0.155	14.5	36.9	+0.744**	−0.884***
RRIM 607	V	2	3.0	38.2	0.164	11.3	39.0	+0.841***	−0.897***
RRIM 623	VII	1	4.0	33.0	0.148	9.2	36.9	+0·652*	−0.796**
RRIM 623	VII	2	4.0	39.6	0.154	6.9	37.0	+0.556*	−0.617*
RRIM 628	VII	1	3.8	23.9	0.127	16.3	33.4	+0.437	−0.703**
RRIM 628	VII	2	5.0	24.4	0.115	15.7	34.3	+0.152	−0.515
RRIM 628	VIII	1	3.8	22.1	0.137	17.6	31.7	+0.512	−0.761**
RRIM 628	VIII	2	3.5	25.6	0.138	13.1	37.2	+0.488	−0.766**
RRIM 701	VII	1	3.4	31.5	0.152	23.1	30.2	−0.078	−0.712**

* $P = <0.05$ ** $P = <0.01$ *** $P = <0.001$

yield and respectively late drip and d.r.c. are between tapping treatments within years and experiments. Although in most cases the correlations between yield and late drip are positive and those with d.r.c. negative, there are significant exceptions.

The Panel B experiments *(Table 4)* agree in that there is no consistent trend with successive years of tapping in either increments or relative growth rates, although they are generally smaller for the Panel B than in the Panel A experiments. There are clear trends of declining percentage late drip and increasing d.r.c. with age, both within the Panel B experiments and comparing them with those for Panel A. The significant correlations are negative between yield and both late drip and d.r.c. for Panel B. In neither the Panel A nor the Panel B experiments is there any obvious relationship – compared between clones or experiments – of the mean yield with either the mean increment or relative growth rate as given in *Tables 2, 3* and *4*.

Regression Analysis of Increments on other Variables

The linear regressions of estimated increment in dry weight on yield (between tapping treatments within experiments and years

TABLE 4. MEANS OF YIELD, ESTIMATED INCREASE IN DRY WEIGHT, RELATIVE GROWTH RATE, PERCENTAGE LATE DRIP, PERCENTAGE DRY RUBBER CONTENT AND CORRELATION COEFFICIENTS BETWEEN YIELD AND RESPECTIVELY LATE DRIP AND D.R.C. (PANEL B EXPERIMENTS)

Clone	Estate	Year	Yield (kg)	Increased dry weight (kg)	Relative growth rate (kg/kg/year)	Late drip (%)	d.r.c. (%)	r: yield and late drip	r: yield and d.r.c.
PB 86	I	1	5.6	31.7	0.078	5.1	35.4	+0.562	−0.940*
PB 86	I	2	6.4	31.0	0.071	6.8	37.5	+0.050	−0.674
PB 86	I	3	6.0	11.0	0.024	2.5	39.2	−0.175	−0.468
PB 86	I	4	5.7	20.8	0.044	1.5	36.8	−0.607	−0.034
PB 86	I	5	6.3	26·1	0.052	1.9	40.4	−0.695	+0.006
PR 107	I	1	7.3	26.6	0.058	7.2	35.7	+0.399	−0.811
PR 107	I	2	8.3	44.0	0.089	7.4	38.4	+0.344	−0.255
PR 107	I	3	7.8	34.7	0.065	4.8	40.2	−0.008	−0.932*
PR 107	I	4	8.0	46.1	0.080	4.2	40.0	+0.080	−0.846
PR 107	I	5	7.5	50.9	0.082	3.3	42.2	+0.539	−0.740
RRIM 501	I	1	8.1	11.2	0.035	17.4	37.6	+0.333	−0.880*
RRIM 501	I	2	8.7	20.4	0.059	21.9	38.1	−0.844	−0.383
PB 5/51	IV	1	5.3	19.4	0.054	16.0	39.2	−0.952*	−0.947*
PB 5/51	IV	2	7.1	20.6	0.055	11.3	41.5	−0.960**	−0.643
PB 5/51	IV	3	5.3	14.5	0.037	0.7	44.3	−0.655	−0.187
PB 5/51	IV	4	4.4	12.7	0.031	0.9	42.3	−0.777	+0.317
PB 5/51	IV	5	3.8	18.3	0.043	0.4	42.6	−0.605	+0.674
PR 107	IV	1	5.4	27.3	0.056	13.5	36.0	−0.377	−0.986**
PR 107	IV	2	6.9	27.6	0.054	6.2	38.4	+0.026	−0.955*
PR 107	IV	3	6.8	32.4	0.059	2.4	38.7	+0.168	−0.717
PR 107	IV	4	6.5	23.9	0.041	1.5	40.2	+0.016	−0.645
PR 107	IV	5	5.9	38.7	0.064	2.1	40.4	−0.267	+0.130
RRIM 513	IV	1	6.4	13.6	0.042	18.5	35.7	−0.045	−0.930*
RRIM 513	IV	2	6.6	13.2	0.039	8.3	38.3	−0.745	−0.243
RRIM 513	IV	3	5.9	14.3	0.041	6.4	40.0	−0.707	+0.213
RRIM 513	IV	4	5.0	10.1	0.028	3.8	41.0	−0.749	+0.381
RRIM 513	IV	5	4.6	23.7	0.062	3.9	40.2	−0.898*	+0.585

* P = <0.05 ** P = <0.01

of tapping) are given in *Tables 5, 6* and *7*. The regressions including and excluding the untapped trees for the Panel A experiments are given in *Tables 5* and *6*. The significant regressions are all negative with two exceptions out of sixty cases for Panel A including untapped trees and with one exception out of thirty-one excluding untapped trees; the exceptions are all in the fourth or fifth year of tapping, when the 'untapped trees' had been brought into tapping *(Table 5)*. In the majority of cases (*i.e.* thirty-eight out of fifty-four) for the first three years of tapping, when the untapped trees were being rested, both the intercepts and the negative regression coefficients are greater in magnitude when the untapped trees are included.

All trees in the Panel B experiments were tapped *(Table 7)*. The regression coefficients are roughly evenly divided between the negative and the positive; none are significant largely owing to the small number of observations. The Panel B experiments continue a trend in the Panel A experiments for the magnitude of the negative regression coefficients during the early years to decline with age and/or to be reversed in sign. The regressions of the relative growth rates on yield given in *Tables 7, 8* and *9* display

TABLE 5. REGRESSION OF ESTIMATED INCREMENT IN DRY WEIGHT (KG) ON YIELD (KG) PER YEAR (PANEL A EXPERIMENTS)

Clone	Estate	Year	Regression including untapped trees ($n = 11$)		Regression for tapped trees only ($n = 10$)	
GT 1	I	1	$y = 116.1 - 17.98\,x$	$r = -0.954$***	$y = 124.3 - 20.23\,x$	$r = -0.901$***
GT 1	I	2	$y = 115.2 - 14.92\,x$	$r = -0.978$***	$y = 124.5 - 17.05\,x$	$r = -0.955$***
GT 1	I	3	$y = 102.3 - 12.02\,x$	$r = -0.971$***	$y = 75.4 - 6.71\,x$	$r = -0.676$*
GT 1	I	4[a]	$y = 52.9 - 2.66\,x$	$r = -0.308$	$y = 38.3 + 0.70\,x$	$r = +0.125$
GT 1	I	5[a]	$y = 63.7 - 5.23\,x$	$r = -0.447$	$y = 21.1 + 25.91\,x$	$r = +0.688$*
RRIM 605	I	1	$y = 79.0 - 9.09\,x$	$r = -0.933$***	$y = 72.7 - 7.74\,x$	$r = -0.655$*
RRIM 605	I	2	$y = 85.6 - 6.67\,x$	$r = -0.859$***	$y = 83.5 - 6.34\,x$	$r = -0.533$
RRIM 605	I	3	$y = 87.1 - 7.19\,x$	$r = -0.883$***	$y = 55.4 - 2.15\,x$	$r = -0.241$
RRIM 605	I	4[a]	$y = 3.2 + 6.25\,x$	$r = +0.795$**	$y = 21.2 + 3.51\,x$	$r = +0.298$
RRIM 623	I	1	$y = 97.7 - 11.43\,x$	$r = -0.865$***	$y = 85.3 - 8.80\,x$	$r = -0.447$
RRIM 623	I	2	$y = 95.3 - 8.64\,x$	$r = -0.771$**	$y = 101.8 - 9.92\,x$	$r = -0.492$
RRIM 623	I	3	$y = 108.6 - 11.76\,x$	$r = -0.835$**	$y = 104.4 - 10.92\,x$	$r = -0.517$
RRIM 623	I	4[a]	$y = 12.2 + 7.90\,x$	$r = +0.711$*	$y = 43.3 + 1.81\,x$	$r = +0.150$
GT 1	II	1	$y = 76.0 - 17.42\,x$	$r = -0.908$***	$y = 91.9 - 23.99\,x$	$r = -0.830$**
GT 1	II	2	$y = 75.4 - 14.70\,x$	$r = -0.935$***	$y = 88.8 - 19.22\,x$	$r = -0.926$***
GT 1	II	3	$y = 72.4 - 12.18\,x$	$r = -0.943$***	$y = 78.8 - 14.02\,x$	$r = -0.891$***
GT 1	II	4[a]	$y = 77.1 - 14.05\,x$	$r = -0.819$**	$y = 72.5 - 12.37\,x$	$r = -0.775$*
GT 1	II	5[a]	$y = 137.5 - 20.89\,x$	$r = -0.861$***	$y = 140.9 - 21.81\,x$	$r = -0.809$**
PB 5/51	II	1	$y = 54.4 - 11.39\,x$	$r = -0.880$***	$y = 35.3 - 3.91\,x$	$r = -0.239$
PB 5/51	II	2	$y = 40.3 - 5.37\,x$	$r = -0.636$*	$y = 29.3 - 1.21\,x$	$r = -0.109$
PB 5/51	II	3	$y = 45.2 - 8.09\,x$	$r = -0.743$**	$y = 19.1 + 0.89\,x$	$r = +0.107$
PB 5/51	II	4[a]	$y = 25.0 - 1.80\,x$	$r = -0.350$	$y = 19.1 + 1.30\,x$	$r = +0.233$
PB 5/51	II	5[a]	$y = 31.7 - 0.41\,x$	$r = -0.039$	$y = 15.7 + 4.52\,x$	$r = +0.381$
PB 5/63	II	1	$y = 53.8 - 12.25\,x$	$r = -0.925$***	$y = 37.5 - 5.98\,x$	$r = -0.457$
PB 5/63	II	2	$y = 30.2 - 4.31\,x$	$r = -0.966$***	$y = 31.4 - 4.67\,x$	$r = -0.876$***
PB 5/63	II	3	$y = 49.0 - 5.34\,x$	$r = -0.931$***	$y = 47.4 - 4.97\,x$	$r = -0.750$*
PB 5/63	II	4[a]	$y = 30.9 - 1.98\,x$	$r = -0.238$	$y = 31.2 - 2.02\,x$	$r = -0.244$
PB 5/63	II	5[a]	$y = -3.8 + 6.83\,x$	$r = +0.586$	$y = -3.8 + 6.92\,x$	$r = +0.600$
RRIM 513	II	1	$y = 55.7 - 14.62\,x$	$r = -0.897$***	$y = 23.4 - 2.77\,x$	$r = -0.222$
RRIM 513	II	2	$y = 60.0 - 11.01\,x$	$r = -0.864$***	$y = 37.5 - 3.22\,x$	$r = -0.301$
RRIM 513	II	3	$y = 49.1 - 7.68\,x$	$r = -0.892$***	$y = 27.4 - 1.87\,x$	$r = -0.283$
RRIM 513	II	4[a]	$y = 64.7 - 8.88\,x$	$r = -0.450$	$y = 53.7 - 5.71\,x$	$r = -0.395$
RRIM 513	II	5[a]	$y = 31.0 - 1.25\,x$	$r = -0.115$	$y = 24.3 + 0.31\,x$	$r = +0.022$
RRIM 600	II	1	$y = 55.6 - 8.47\,x$	$r = -0.854$***	$y = 56.6 - 8.83\,x$	$r = -0.461$
RRIM 600	II	2	$y = 69.0 - 6.10\,x$	$r = -0.874$***	$y = 66.6 - 5.52\,x$	$r = -0.579$
RRIM 600	II	3	$y = 96.2 - 7.57\,x$	$r = -0.878$***	$y = 98.8 - 8.12\,x$	$r = -0.662$*
RRIM 600	II	4[a]	$y = 70.2 - 5.85\,x$	$r = -0.625$*	$y = 64.3 - 4.47\,x$	$r = -0.460$
RRIM 600	II	5[a]	$y = 61.1 - 4.34\,x$	$r = -0.560$	$y = 60.7 - 4.26\,x$	$r = -0.435$
RRIM 605	II	1	$y = 55.3 - 10.03\,x$	$r = -0.912$***	$y = 44.9 - 6.64\,x$	$r = -0.522$
RRIM 605	II	2	$y = 50.3 - 7.85\,x$	$r = -0.934$***	$y = 54.9 - 9.25\,x$	$r = -0.680$*
RRIM 605	II	3	$y = 67.9 - 9.38\,x$	$r = -0.784$**	$y = 30.6 + 0.62\,x$	$r = +0.041$
RRIM 605	II	4[a]	$y = 48.7 - 5.61\,x$	$r = -0.381$	$y = 45.5 - 4.72\,x$	$r = -0.201$
RRIM 605	II	5[a]	$y = 23.7 - 0.27\,x$	$r = -0.045$	$y = 14.6 + 1.81\,x$	$r = +0.141$
RRIM 607	II	1	$y = 65.4 - 14.56\,x$	$r = -0.967$***	$y = 70.8 - 16.51\,x$	$r = -0.893$***
RRIM 607	II	2	$y = 74.8 - 12.41\,x$	$r = -0.958$***	$y = 84.8 - 15.41\,x$	$r = -0.926$***
RRIM 607	II	3	$y = 63.1 - 10.20\,x$	$r = -0.958$***	$y = 59.8 - 9.20\,x$	$r = -0.792$**
RRIM 607	II	4[a]	$y = 56.5 - 7.14\,x$	$r = -0.746$**	$y = 59.0 - 7.95\,x$	$r = -0.617$*
RRIM 607	II	5[a]	$y = 66.6 - 5.15\,x$	$r = -0.436$	$y = 82.2 - 9.01\,x$	$r = -0.413$
RRIM 623	II	1	$y = 51.5 - 11.22\,x$	$r = -0.918$***	$y = 36.9 - 5.42\,x$	$r = -0.445$
RRIM 623	II	2	$y = 68.2 - 12.62\,x$	$r = -0.906$***	$y = 70.2 - 13.31\,x$	$r = -0.677$*
RRIM 623	II	3	$y = 66.8 - 8.99\,x$	$r = -0.800$**	$y = 44.2 - 1.94\,x$	$r = -0.171$
RRIM 623	II	4[a]	$y = 44.5 - 1.74\,x$	$r = -0.133$	$y = 34.7 + 1.62\,x$	$r = +0.107$
RRIM 623	II	5[a]	$y = 49.3 - 3.63\,x$	$r = -0.415$	$y = 47.2 - 3.00\,x$	$r = -0.228$

[a] In the fourth and fifth years the previously untapped trees were tapped S/1 d/4 100%. These trees are included throughout under the column headed 'including untapped trees' and are excluded throughout from the column headed 'tapped trees' only.

* $P = <0.05$ ** $P = <0.01$ *** $P = <0.001$

TABLE 6. REGRESSION OF ESTIMATED INCREMENT IN DRY WEIGHT (KG) ON YIELD (KG) PER YEAR (FURTHER PANEL A EXPERIMENTS)

Clone	Estate	Year	Regression including untapped trees (n = 14)		Regression for tapped trees only (n = 13)	
GT 1	VI	1	$y = 75.2 - 12.21\,x$	$r = -0.905$***	$y = 73.4 - 11.64\,x$	$r = -0.832$***
GT 1	VI	2	$y = 87.0 - 9.81\,x$	$r = -0.822$***	$y = 72.1 - 6.79\,x$	$r = -0.5333$
PB 5/51	VII	1	$y = 67.1 - 14.08\,x$	$r = -0.956$***	$y = 65.4 - 13.36\,x$	$r = -0.917$***
PB 5/51	VII	2	$y = 73.7 - 11.26\,x$	$r = -0.867$***	$y = 87.2 - 15.59\,x$	$r = -0.821$***
PB 28/59	VII	1	$y = 53.1 - 7.97\,x$	$r = -0.746$**	$y = 36.8 - 3.03\,x$	$r = -0.321$
PB 28/59	VII	2	$y = 63.7 - 5.61\,x$	$r = -0.779$**	$y = 23.7 + 0.59\,x$	$r = +0.135$
PB 28/59	VIII	1	$y = 49.9 - 8.88\,x$	$r = -0.907$***	$y = 30.6 - 3.81\,x$	$r = -0.714$**
PB 28/59	VIII	2	$y = 36.1 - 2.91\,x$	$r = -0.722$**	$y = 25.1 - 0.73\,x$	$r = -0.125$
RRIM 600	VI	1	$y = 66.0 - 10.03\,x$	$r = -0.853$***	$y = 57.1 - 7.20\,x$	$r = -0.437$
RRIM 600	VI	2	$y = 70.7 - 6.57\,x$	$r = -0.855$***	$y = 71.8 - 6.85\,x$	$r = -0.741$**
RRIM 605	VI	1	$y = 61.3 - 8.48\,x$	$r = -0.865$***	$y = 50.7 - 5.72\,x$	$r = -0.501$
RRIM 605	VI	2	$y = 72.3 - 6.08\,x$	$r = -0.845$***	$y = 63.9 - 4.18\,x$	$r = -0.585$*
RRIM 607	V	1	$y = 68.0 - 11.81\,x$	$r = -0.944$***	$y = 62.8 - 10.29\,x$	$r = -0.887$***
RRIM 607	V	2	$y = 59.6 - 6.93\,x$	$r = -0.716$**	$y = 54.1 - 5.26\,x$	$r = -0.519$
RRIM 623	VII	1	$y = 74.0 - 10.30\,x$	$r = -0.922$***	$y = 81.1 - 11.98\,x$	$r = -0.876$***
RRIM 623	VII	2	$y = 64.0 - 5.97\,x$	$r = -0.743$**	$y = 54.8 - 3.77\,x$	$r = -0.399$
RRIM 628	VII	1	$y = 56.3 - 8.50\,x$	$r = -0.905$***	$y = 42.4 - 4.94\,x$	$r = -0.682$*
RRIM 628	VII	2	$y = 62.5 - 7.55\,x$	$r = -0.894$***	$y = 57.4 - 6.56\,x$	$r = -0.698$**
RRIM 628	VIII	1	$y = 48.6 - 6.95\,x$	$r = -0.943$***	$y = 42.8 - 5.47\,x$	$r = -0.849$***
RRIM 628	VIII	2	$y = 40.0 - 4.14\,x$	$r = -0.880$***	$y = 42.9 - 4.76\,x$	$r = -0.816$***
RRIM 701	VII	1	$y = 88.1 - 16.24\,x$	$r = -0.856$***	$y = 58.4 - 7.80\,x$	$r = -0.427$

* P = <0.05   ** P = <0.01   *** P = <0.001

TABLE 7. REGRESSION OF ESTIMATED INCREMENT IN DRY WEIGHT (KG) AND OF ESTIMATED RELATIVE GROWTH RATE (KG/KG/YEAR) ON YIELD (KG) (PANEL B EXPERIMENTS)

Clone	Estate	Year	Estimated increment in dry weight ($n = 5$)		Relative growth rate ($n = 5$)	
PB 86	I	1	$y = 69.4 - 6.75x$	$r = -0.702$	$y = 0.158 - 0.0143x$	$r = -0.647$
PB 86	I	2	$y = 72.6 - 6.51x$	$r = -0.608$	$y = 0.131 - 0.0095x$	$r = -0.472$
PB 86	I	3	$y = 21.8 - 1.81x$	$r = -0.424$	$y = 0.042 - 0.0030x$	$r = -0.390$
PB 86	I	4	$y = 0.9 + 3.49x$	$r = +0.617$	$y = 0.003 + 0.0071x$	$r = +0.730$
PB 86	I	5	$y = -9.8 + 5.74x$	$r = +0.477$	$y = 0.025 + 0.0123x$	$r = +0.612$
PR 107	I	1	$y = 50.6 - 3.26x$	$r = -0.472$	$y = 0.114 - 0.0076x$	$r = -0.501$
PR 107	I	2	$y = 43.2 + 0.09x$	$r = +0.015$	$y = 0.091 - 0.0002x$	$r = -0.021$
PR 107	I	3	$y = 38.3 - 0.46x$	$r = -0.107$	$y = 0.080 - 0.0019x$	$r = -0.230$
PR 107	I	4	$y = 40.5 + 0.69x$	$r = +0.085$	$y = 0.083 - 0.0004x$	$r = -0.033$
PR 107	I	5	$y = 117.4 - 8.82x$	$r = -0.645$	$y = 0.185 - 0.0137x$	$r = -0.718$
RRIM 501	I	1	$y = 25.8 - 1.81x$	$r = -0.708$	$y = 0.080 - 0.0057x$	$r = -0.720$
RRIM 501	I	2	$y = 2.0 + 2.10x$	$r = +0.632$	$y = 0.004 + 0.0062x$	$r = +0.681$
PB 5/51	IV	1	$y = 29.6 - 1.95x$	$r = -0.729$	$y = 0.079 - 0.0049x$	$r = -0.715$
PB 5/51	IV	2	$y = 26.2 - 0.80x$	$r = -0.356$	$y = 0.062 - 0.0010x$	$r = -0.182$
PB 5/51	IV	3	$y = 18.1 - 0.67x$	$r = -0.434$	$y = 0.044 - 0.0014x$	$r = -0.450$
PB 5/51	IV	4	$y = 7.4 + 1.20x$	$r = +0.529$	$y = 0.018 + 0.0029x$	$r = +0.604$
PB 5/51	IV	5	$y = 1.1 + 4.49x$	$r = +0.532$	$y = 0.006 + 0.0097x$	$r = +0.453$
PR 107	IV	1	$y = 42.1 - 2.75x$	$r = -0.412$	$y = 0.089 - 0.0061x$	$r = -0.456$
PR 107	IV	2	$y = 26.4 + 0.18x$	$r = +0.033$	$y = 0.052 + 0.0002x$	$r = +0.019$
PR 107	IV	3	$y = 14.8 + 2.59x$	$r = +0.274$	$y = 0.034 + 0.0037x$	$r = +0.254$
PR 107	IV	4	$y = 14.2 + 1.49x$	$r = +0.141$	$y = 0.036 + 0.0009x$	$r = +0.058$
PR 107	IV	5	$y = 80.3 - 7.05x$	$r = -0.289$	$y = 0.140 - 0.0129x$	$r = -0.397$
RRIM 513	IV	1	$y = 19.6 - 0.94x$	$r = -0.488$	$y = 0.065 - 0.0037x$	$r = -0.617$
RRIM 513	IV	2	$y = 13.3 - 0.02x$	$r = -0.023$	$y = 0.044 - 0.0008x$	$r = -0.269$
RRIM 513	IV	3	$y = 0.2 + 2.41x$	$r = +0.617$	$y = 0.007 + 0.0058x$	$r = +0.555$
RRIM 513	IV	4	$y = 6.0 + 0.81x$	$r = +0.210$	$y = 0.025 + 0.0006x$	$r = +0.055$
RRIM 513	IV	5	$y = -6.9 + 6.70x$	$r = +0.859$	$y = -0.001 + 0.0138x$	$r = +0.796$

TABLE 8. REGRESSION OF ESTIMATED RELATIVE GROWTH RATE (KG/KG/YEAR) ON YIELD (KG/YEAR) (PANEL A EXPERIMENTS)

Clone	Estate	Year	Regression including untapped trees ($n = 11$)		Regression for tapped trees only ($n = 10$)	
GT 1	I	1	$y = 0.473 - 0.0671x$	$r = -0.942$***	$y = 0.525 - 0.0814x$	$r = -0.901$***
GT 1	I	2	$y = 0.325 - 0.0324x$	$r = -0.955$***	$y = 0.370 - 0.0429x$	$r = -0.952$***
GT 1	I	3	$y = 0.218 - 0.0175x$	$r = -0.960$***	$y = 0.180 - 0.0100x$	$r = -0.586$
GT 1	I	4[a]	$y = 0.171 - 0.0127x$	$r = -0.549$	$y = 0.130 - 0.0031x$	$r = -0.508$
GT 1	I	5[a]	$y = 0.166 - 0.0168x$	$r = -0.700$*	$y = 0.006 + 0.0418x$	$r = +0.781$**
RRIM 605	I	1	$y = 0.347 - 0.0368x$	$r = -0.928$***	$y = 0.338 - 0.0348x$	$r = -0.675$*
RRIM 605	I	2	$y = 0.279 - 0.0161x$	$r = -0.787$**	$y = 0.301 - 0.0198x$	$r = -0.529$
RRIM 605	I	3	$y = 0.221 - 0.0126x$	$r = -0.863$***	$y = 0.173 - 0.0050x$	$r = -0.270$
RRIM 605	I	4[a]	$y = 0.014 + 0.0177x$	$r = +0.849$***	$y = 0.089 + 0.0061x$	$r = +0.250$
RRIM 623	I	1	$y = 0.337 - 0.0369x$	$r = -0.851$***	$y = 0.304 - 0.0299x$	$r = -0.440$
RRIM 623	I	2	$y = 0.250 - 0.0173x$	$r = -0.687$*	$y = 0.288 - 0.0249x$	$r = -0.488$
RRIM 623	I	3	$y = 0.226 - 0.0185x$	$r = -0.773$**	$y = 0.242 - 0.0216x$	$r = -0.524$
RRIM 623	I	4[a]	$y = 0.036 + 0.0186x$	$r = +0.706$*	$y = 0.126 - 0.0009x$	$r = +0.035$
GT 1	II	1	$y = 0.392 - 0.0828x$	$r = -0.884$***	$y = 0.494 - 0.1244x$	$r = -0.827$**
GT 1	II	2	$y = 0.293 - 0.0481x$	$r = -0.888$***	$y = 0.368 - 0.0733x$	$r = -0.927$***
GT 1	II	3	$y = 0.222 - 0.0286x$	$r = -0.885$***	$y = 0.258 - 0.0390x$	$r = -0.862$**
GT 1	II	4[a]	$y = 0.223 - 0.0344x$	$r = -0.720$*	$y = 0.189 - 0.0218x$	$r = -0.721$*
GT 1	II	5[a]	$y = 0.346 - 0.0462x$	$r = -0.862$***	$y = 0.294 - 0.0321x$	$r = -0.764$*
PB 5/51	II	1	$y = 0.288 - 0.0547x$	$r = -0.858$***	$y = 0.202 - 0.0215x$	$r = -0.238$
PB 5/51	II	2	$y = 0.174 - 0.0157x$	$r = -0.507$	$y = 0.149 - 0.0062x$	$r = -0.127$
PB 5/51	II	3	$y = 0.162 - 0.0223x$	$r = -0.711$*	$y = 0.090 + 0.0025x$	$r = +0.090$
PB 5/51	II	4[a]	$y = 0.112 - 0.0124x$	$r = -0.563$	$y = 0.082 + 0.0033x$	$r = +0.222$
PB 5/51	II	5[a]	$y = 0.130 - 0.0055x$	$r = -0.169$	$y = 0.069 + 0.0132x$	$r = +0.408$
PB 5/63	II	1	$y = 0.313 - 0.0661x$	$r = -0.913$***	$y = 0.234 - 0.0358x$	$r = -0.446$
PB 5/63	II	2	$y = 0.143 - 0.0162x$	$r = -0.935$***	$y = 0.166 - 0.0228x$	$r = -0.889$**
PB 5/63	II	3	$y = 0.198 - 0.0150x$	$r = -0.855$***	$y = 0.220 - 0.0201x$	$r = -0.742$*
PB 5/63	II	4[a]	$y = 0.115 - 0.0032x$	$r = -0.095$	$y = 0.121 - 0.0040x$	$r = -0.143$
PB 5/63	II	5[a]	$y = -0.036 + 0.0315x$	$r = +0.655$	$y = 0.036 + 0.0323x$	$r = +0.732$*
RRIM 513	II	1	$y = 0.296 - 0.0734x$	$r = -0.886$***	$y = 0.140 - 0.0160x$	$r = -0.221$
RRIM 513	II	2	$y = 0.248 - 0.0337x$	$r = -0.815$**	$y = 0.200 - 0.0170x$	$r = -0.341$
RRIM 513	II	3	$y = 0.162 - 0.0174x$	$r = -0.849$**	$y = 0.123 - 0.0069x$	$r = -0.298$
RRIM 513	II	4[a]	$y = 0.250 - 0.0322x$	$r = -0.386$	$y = 0.191 - 0.0152x$	$r = -0.331$
RRIM 513	II	5[a]	$y = 0.151 - 0.0131x$	$r = -0.368$	$y = 0.100 - 0.0008x$	$r = -0.022$
RRIM 600	II	1	$y = 0.313 - 0.0421x$	$r = -0.835$**	$y = 0.355 - 0.0568x$	$r = -0.533$
RRIM 600	II	2	$y = 0.289 - 0.0175x$	$r = -0.770$**	$y = 0.297 - 0.0196x$	$r = -0.509$
RRIM 600	II	3	$y = 0.304 - 0.0140x$	$r = -0.760$*	$y = 0.338 - 0.0212x$	$r = -0.642$*
RRIM 600	II	4[a]	$y = 0.221 - 0.0181x$	$r = -0.656$*	$y = 0.173 - 0.0070x$	$r = -0.382$
RRIM 600	II	5[a]	$y = 0.173 - 0.0123x$	$r = -0.708$*	$y = 0.146 - 0.0071x$	$r = -0.426$
RRIM 605	II	1	$y = 0.323 - 0.0537x$	$r = -0.897$***	$y = 0.287 - 0.0418x$	$r = -0.534$
RRIM 605	II	2	$y = 0.225 - 0.0271x$	$r = -0.880$***	$y = 0.280 - 0.0439x$	$r = -0.692$*
RRIM 605	II	3	$y = 0.242 - 0.0228x$	$r = -0.670$*	$y = 0.149 + 0.0021x$	$r = +0.037$
RRIM 605	II	4[a]	$y = 0.221 - 0.0289x$	$r = -0.527$	$y = 0.181 - 0.0178x$	$r = -0.223$
RRIM 605	II	5[a]	$y = 0.105 - 0.0049x$	$r = -0.273$	$y = 0.058 + 0.0056x$	$r = +0.158$
RRIM 607	II	1	$y = 0.335 - 0.0704x$	$r = -0.956$***	$y = 0.387 - 0.0890x$	$r = -0.896$***
RRIM 607	II	2	$y = 0.292 - 0.0394x$	$r = -0.901$***	$y = 0.363 - 0.0610x$	$r = -0.916$***
RRIM 607	II	3	$y = 0.193 - 0.0219x$	$r = -0.919$***	$y = 0.201 - 0.0243x$	$r = -0.743$*
RRIM 607	II	4[a]	$y = 0.208 - 0.0272x$	$r = -0.875$***	$y = 0.189 - 0.0210x$	$r = -0.679$*
RRIM 607	II	5[a]	$y = 0.221 - 0.0191x$	$r = -0.654$*	$y = 0.221 - 0.0192x$	$r = -0.412$
RRIM 623	II	1	$y = 0.246 - 0.0500x$	$r = -0.911$***	$y = 0.194 - 0.0291x$	$r = -0.472$
RRIM 623	II	2	$y = 0.257 - 0.0401x$	$r = -0.853$**	$y = 0.301 - 0.0547x$	$r = -0.686$*
RRIM 623	II	3	$y = 0.204 - 0.0175x$	$r = -0.715$*	$y = 0.173 - 0.0077x$	$r = -0.226$
RRIM 623	II	4[a]	$y = 0.171 - 0.0130x$	$r = -0.323$	$y = 0.122 + 0.0039x$	$r = +0.102$
RRIM 623	II	5[a]	$y = 0.164 - 0.0159x$	$r = -0.733$*	$y = 0.141 - 0.0088x$	$r = -0.371$

[a]In the fourth and fifth years the previously untapped trees were tapped S/1 d/4 100%. These trees are included throughout under the column headed 'including untapped trees' and are excluded throughout from the column headed 'tapped trees only'.

* $P = <0.05$ ** $P = <0.01$ *** $P = <0.001$

TABLE 9. REGRESSION OF ESTIMATED RELATIVE GROWTH RATE (KG/KG/YEAR) ON YIELD (KG/YEAR) (FURTHER PANEL A EXPERIMENTS)

Clone	Estate	Year	Regression including untapped trees (n = 14)		Regression for tapped trees only (n = 13)	
GT 1	VI	1	$y = 0.367 - 0.0561\,x$	$r = -0.902$***	$y = 0.368 - 0.0566\,x$	$r = -0.839$***
GT 1	VI	2	$y = 0.300 - 0.0781\,x$	$r = -0.711$**	$y = 0.264 - 0.0199\,x$	$r = -0.409$
PB 5/51	VII	1	$y = 0.361 - 0.0690\,x$	$r = -0.949$***	$y = 0.366 - 0.0711\,x$	$r = -0.916$***
PB 5/51	VII	2	$y = 0.285 - 0.0319\,x$	$r = -0.772$**	$y = 0.350 - 0.0526\,x$	$r = -0.781$**
PB 28/59	VII	1	$y = 0.274 - 0.0371\,x$	$r = -0.730$**	$y = 0.204 - 0.0158\,x$	$r = -0.324$
PB 28/59	VII	2	$y = 0.243 - 0.0166\,x$	$r = -0.740$**	$y = 0.115 - 0.0031\,x$	$r = -0.186$
PB 28/59	VIII	1	$y = 0.249 - 0.0427\,x$	$r = -0.932$***	$y = 0.174 - 0.0229\,x$	$r = -0.817$***
PB 28/59	VIII	2	$y = 0.156 - 0.0099\,x$	$r = -0.567$*	$y = 0.149 - 0.0086\,x$	$r = -0.256$
RRIM 600	VI	1	$y = 0.355 - 0.0478\,x$	$r = -0.827$***	$y = 0.327 - 0.0391\,x$	$r = -0.441$
RRIM 600	VI	2	$y = 0.290 - 0.0188\,x$	$r = -0.777$**	$y = 0.318 - 0.0261\,x$	$r = -0.768$**
RRIM 605	VI	1	$y = 0.344 - 0.0439\,x$	$r = -0.853$***	$y = 0.301 - 0.0327\,x$	$r = -0.510$
RRIM 605	VI	2	$y = 0.305 - 0.0173\,x$	$r = -0.707$**	$y = 0.301 - 0.0163\,x$	$r = -0.501$
RRIM 607	V	1	$y = 0.319 - 0.0523\,x$	$r = -0.944$***	$y = 0.305 - 0.0482\,x$	$r = -0.889$***
RRIM 607	V	2	$y = 0.216 - 0.0169\,x$	$r = -0.550$*	$y = 0.206 - 0.0140\,x$	$r = -0.380$
RRIM 628	VII	1	$y = 0.274 - 0.0385\,x$	$r = -0.903$***	$y = 0.220 - 0.0248\,x$	$r = -0.681$*
RRIM 628	VII	2	$y = 0.242 - 0.0256\,x$	$r = -0.834$***	$y = 0.259 - 0.0287\,x$	$r = -0.688$**
RRIM 628	VIII	1	$y = 0.283 - 0.0382\,x$	$r = -0.942$***	$y = 0.259 - 0.0321\,x$	$r = -0.846$***
RRIM 628	VIII	2	$y = 0.189 - 0.0158\,x$	$r = -0.790$***	$y = 0.211 - 0.0208\,x$	$r = -0.793$**
RRIM 701	VII	1	$y = 0.376 - 0.0641\,x$	$r = -0.839$***	$y = 0.274 - 0.0353\,x$	$r = -0.428$

* $P = < 0.05$ ** $P = < 0.01$ *** $P = < 0.001$

very similar patterns to those for increments in dry weight on yield in *Tables 5, 6* and *7.* The corresponding intercepts and regression coefficients are correlated. The greater intercepts and negative regression coefficients with the untapped trees included than excluded is also evident in most cases.

The regressions of increment in dry weight on percentage late drip and d.r.c. are given in *Tables 10, 11* and *12.* The regressions for increment on late drip are negative (with one exception out of seventy-four cases for Panel A and with four exceptions out of twenty-seven for Panel B). They are significant with eighteen exceptions for Panel A. Only eight are significant for Panel B owing to the small number of observations. The regressions for increment on d.r.c. are positive (with seven exceptions out of sixty-one cases for Panel A and with two exceptions out of twenty-seven for Panel B). They are significant in about half the cases for Panel A, but in only three cases for Panel B.

Deviations from the Regressions

The expected increments in dry weight were calculated from the regressions and the respective independent variables. The difference between the actual increment (strictly that estimated from the girths) and that calculated from the regression (on yield, late drip or d.r.c.) has been computed for every value and expressed as positive if the actual exceeds the calculated. The mean differences for each tapping system in each group of experiments, which have all tapping systems in common, are given in *Tables 13, 14, 15* and *16.* The mean differences in increment, actual less calculated from yield, are – with a few minor exceptions – positive in half spiral (S/2) tapping systems and negative for long cuts (S/R and S/1) in the Panel A experiments on Estates I and II and in all Panel B experiments *(Tables 13* and *16).* This is so for the further Panel A experiments on Estates V to VIII, although there are rather more exceptions. The 2S/2 systems in *Table 14* are long-cut systems; since both cuts are at the same level and tapped on the same day, they also show negative differences between actual and calculated increments. The cuts in the panel-changing systems suffixed (2 × 3d/6) and (2 × 4d/8) are at the same level but are tapped on different days; the differences between actual and calculated increments are variable.

The differences between actual increments and those calculated from the regressions on late drip and d.r.c. are somewhat inconsistent. This can be explained in part for those experiments including periodic systems. The differences for periodic systems tend to be larger positive values than for corresponding continuous systems, as in *Tables 13* and *15* and to a lesser extent in *Table 14* [there are no periodic systems on Panel B *(Table 16)*]. Whereas the increment and yield are total figures for the whole year irrespective of whether tapping is continuous or periodic, the late drip and d.r.c. are averages for the period of tapping only. Therefore, larger differences between actual increments and those calculated from regressions on late drip or d.r.c. are found for periodic systems.

The differences between actual increments and those calculated from late drip display trends from negative to positive values (or from large negative to small negative or from small positive to large positive) with increasing interval between tappings (reduced frequency) for any given length of cut. The reverse trend obtains for the differences between actual increments and those calculated from the d.r.c. The differences between actual increments and those calculated from either late drip or d.r.c. show a trend from positive to negative with increasing length of cut tapped at the same frequency within continuous or periodic systems respectively.

TABLE 10. REGRESSIONS OF ESTIMATED INCREMENT IN DRY WEIGHT (KG) ON RESPECTIVELY PERCENTAGE LATE DRIP AND PERCENTAGE DRY RUBBER CONTENT (PANEL A EXPERIMENTS)

Clone	Estate	Year	Regression on late drip ($n = 10$)		Regression on d.r.c. ($n = 10$)	
GT 1	I	1[a]	$y = 69.8 - 0.135x$	$r = -0.919$***	–	–
GT 1	I	2	$y = 73.3 - 0.110x$	$r = -0.884$***	$y = -290.6 + 0.990x$	$r = +0.657$*
GT 1	I	3	$y = 47.2 - 0.027x$	$r = -0.594$	$y = -9.6 + 0.152x$	$r = +0.466$
GT 1	I	4	$y = 47.0 - 0.029x$	$r = -0.626$	$y = 14.0 + 0.086x$	$r = +0.654$*
GT 1	I	5	$y = 66.2 - 0.092x$	$r = -0.912$***	$y = 0.7 + 0.146x$	$r = +0.438$
RRIM 605	I	1[a]	$y = 48.6 - 0.055x$	$r = -0.775$**	–	–
RRIM 605	I	2[a]	$y = 58.8 - 0.067x$	$r = -0.903$***	–	–
RRIM 605	I	3	$y = 52.0 - 0.054x$	$r = -0.899$***	$y = 38.3 + 0.010x$	$r = +0.024$
RRIM 605	I	4	$y = 58.6 - 0.093x$	$r = -0.884$***	$y = -43.9 + 0.229x$	$r = +0.590$
RRIM 623	I	1[a]	$y = 63.5 - 0.101x$	$r = -0.843$**	–	–
RRIM 623	I	2[a]	$y = 67.2 - 0.099x$	$r = -0.912$***	–	–
RRIM 623	I	3	$y = 65.1 - 0.114x$	$r = -0.854$**	$y = -270.9 + 0.858x$	$r = +0.861$**
RRIM 623	I	4	$y = 63.4 - 0.093x$	$r = -0.790$**	$y = -51.2 + 0.269x$	$r = +0.645$*
GT 1	II	1[a]	$y = 48.0 - 0.124x$	$r = -0.931$***	–	–
GT 1	II	2	$y = 46.7 - 0.171x$	$r = -0.898$***	$y = -92.5 + 0.349x$	$r = +0.946$***
GT 1	II	3	$y = 43.8 - 0.187x$	$r = -0.958$***	$y = -72.3 + 0.293x$	$r = +0.862$**
GT 1	II	4	$y = 43.1 - 0.188x$	$r = -0.946$***	$y = -53.2 + 0.249x$	$r = +0.947$***
GT 1	II	5	$y = 70.6 - 0.287x$	$r = -0.952$***	$y = -124.6 + 0.514x$	$r = +0.904$***
PB 5/51	II	1[a]	$y = 32.4 - 0.079x$	$r = -0.795$**	–	–
PB 5/51	II	2	$y = 31.5 - 0.084x$	$r = -0.808$**	$y = -76.4 + 0.267x$	$r = +0.754$*
PB 5/51	II	3	$y = 25.9 - 0.090x$	$r = -0.770$**	$y = -26.4 + 0.126x$	$r = +0.819$**
PB 5/51	II	4	$y = 24.3 - 0.074x$	$r = -0.827$**	$y = -3.4 + 0.064x$	$r = +0.694$*
PB 5/51	II	5	$y = 40.2 - 0.294x$	$r = -0.847$**	$y = -52.6 + 0.216x$	$r = +0.581$
PB 5/63	II	1[a]	$y = 30.0 - 0.068x$	$r = -0.760$*	–	–
PB 5/63	II	2	$y = 17.7 - 0.014x$	$r = -0.356$	$y = 44.6 - 0.102x$	$r = -0.505$
PB 5/63	II	3	$y = 31.1 - 0.021x$	$r = -0.802$**	$y = 84.7 - 0.197x$	$r = -0.289$
PB 5/63	II	4	$y = 30.8 - 0.035x$	$r = -0.576$	$y = 62.2 - 0.130x$	$r = -0.630$
PB 5/63	II	5	$y = 41.6 - 0.080x$	$r = -0.779$**	$y = -0.4 + 0.091x$	$r = +0.304$
RRIM 513	II	1[a]	$y = 29.6 - 0.117x$	$r = -0.759$*	–	–
RRIM 513	II	2	$y = 35.5 - 0.137x$	$r = -0.836$**	$y = -35.6 + 0.173x$	$r = +0.848$**
RRIM 513	II	3	$y = 24.4 - 0.097x$	$r = -0.661$*	$y = -14.6 + 0.097x$	$r = +0.687$*
RRIM 513	II	4	$y = 37.8 - 0.256x$	$r = -0.924$***	$y = -25.1 + 0.154x$	$r = +0.668$*
RRIM 513	II	5	$y = 29.6 - 0.163x$	$r = -0.507$	$y = -31.3 + 0.155x$	$r =$ *0.806**
RRIM 600	II	1[a]	$y = 42.3 - 0.062x$	$r = -0.750$*	–	–
RRIM 600	II	2	$y = 53.7 - 0.047x$	$r = -0.611$	$y = -26.8 + 0.205x$	$r = +0.529$
RRIM 600	II	3	$y = 73.2 - 0.140x$	$r = -0.810$**	$y = -34.1 + 0.274x$	$r = +0.731$*
RRIM 600	II	4	$y = 48.6 - 0.126x$	$r = -0.748$*	$y = +0.5 + 0.120x$	$r = +0.546$
RRIM 600	II	5	$y = 42.9 - 0.140x$	$r = -0.687$*	$y = -26.5 + 0.140x$	$r = +0.639$*
RRIM 605	II	1[a]	$y = 34.7 - 0.058x$	$r = -0.766$**	–	–
RRIM 605	II	2	$y = 29.6 - 0.036x$	$r = -0.617$	$y = +17.4 + 0.020x$	$r = +0.129$
RRIM 605	II	3	$y = 41.9 - 0.099x$	$r = -0.853$**	$y = -8.0 + 0.112x$	$r = +0.438$
RRIM 605	II	4	$y = 38.0 - 0.136x$	$r = -0.829$**	$y = -5.5 + 0.094x$	$r = +0.280$
RRIM 605	II	5	$y = 27.4 - 0.085x$	$r = -0.612$	$y = -29.6 + 0.144x$	$r = +0.563$
RRIM 607	II	1[a]	$y = 38.5 - 0.087x$	$r = -0.895$***	–	–
RRIM 607	II	2	$y = 47.5 - 0.115x$	$r = -0.891$***	$y = -22.6 + 0.158x$	$r = +0.503$
RRIM 607	II	3	$y = 34.5 - 0.058x$	$r = -0.748$*	$y = -2.3 + 0.087x$	$r = +0.519$
RRIM 607	II	4	$y = 40.7 - 0.090x$	$r = -0.846$**	$y = -23.8 + 0.154x$	$r = +0.648$*
RRIM 607	II	5	$y = 57.9 - 0.170x$	$r = -0.772$**	$y = -32.5 + 0.216x$	$r = +0.508$
RRIM 623	II	1[a]	$y = 27.6 - 0.048x$	$r = -0.607$	–	–
RRIM 623	II	2	$y = 40.3 - 0.086x$	$r = -0.879$***	$y = 12.2 + 0.051x$	$r = +0.235$
RRIM 623	II	3	$y = 43.5 - 0.062x$	$r = -0.779$**	$y = -19.7 + 0.163x$	$r = +0.738$*
RRIM 623	II	4	$y = 47.2 - 0.109x$	$r = -0.867$**	$y = -52.8 + 0.260x$	$r = +0.750$*
RRIM 623	II	5	$y = 41.4 - 0.110x$	$r = -0.696$*	$y = -38.2 + 0.207x$	$r = +0.642$*

[a]d.r.c. was not measured in these years

* P = <0.05 ** P = <0.01 *** P = <0.001

TABLE 11. REGRESSIONS OF ESTIMATED INCREMENT IN DRY WEIGHT (KG) ON RESPECTIVELY PERCENTAGE LATE DRIP AND PERCENTAGE DRY RUBBER CONTENT (FURTHER PANEL A EXPERIMENTS)

Clone	Estate	Year	Regression on late drip (n = 13)		Regression on d.r.c. (n = 13)	
GT 1	VI	1	$y = 60.3 - 0.191\,x$	$r = -0.865$***	$y = -93.1 + 0.374\,x$	$r = 0.711$**
GT 1	VI	2	$y = 48.1 - 0.051\,x$	$r = -0.213$	$y = -56.5 + 0.273\,x$	$r = 0.512$
PB 5/51	VII	1	$y = 48.3 - 0.193\,x$	$r = -0.880$***	$y = -83.5 + 0.335\,x$	$r = 0.831$***
PB 5/51	VII	2	$y = 52.8 - 0.189\,x$	$r = -0.845$***	$y = -71.9 + 0.297\,x$	$r = 0.827$***
PB 28/59	VII	1	$y = 31.2 - 0.020\,x$	$r = -0.171$	$y = 30.7 - 0.009\,x$	$r = -0.026$
PB 28/59	VII	2	$y = 26.1 - 0.007\,x$	$r = -0.003$	$y = 57.1 - 0.084\,x$	$r = -0.317$
PB 28/59	VIII	1	$y = 25.9 - 0.041\,x$	$r = -0.486$	$y = 21.4 - 0.000\,x$	$r = 0.070$
PB 28/59	VIII	2	$y = 12.2 + 0.013\,x$	$r = +0.072$	$y = 32.7 - 0.029\,x$	$r = -0.108$
RRIM 600	VI	1	$y = 59.2 - 0.109\,x$	$r = -0.727$**	$y = -52.7 - 0.293\,x$	$r = 0.483$
RRIM 600	VI	2	$y = 62.5 - 0.099\,x$	$r = -0.804$***	$y = -98.4 - 0.431\,x$	$r = 0.773$***
RRIM 605	VI	1	$y = 52.5 - 0.081\,x$	$r = -0.708$**	$y = 80.6 - 0.157\,x$	$r = -0.488$
RRIM 605	VI	2	$y = 53.8 - 0.045\,x$	$r = -0.358$	$y = -38.7 + 0.229\,x$	$r = 0.604$*
RRIM 607	V	1	$y = 48.1 - 0.120\,x$	$r = -0.837$***	$y = -100.5 + 0.355\,x$	$r = 0.703$**
RRIM 607	V	2	$y = 44.3 - 0.054\,x$	$r = -0.404$	$y = -49.8 + 0.226\,x$	$r = 0.587$*
RRIM 623	VII	1	$y = 54.7 - 0.235\,x$	$r = -0.882$***	$y = -88.8 + 0.330\,x$	$r = 0.589$*
RRIM 623	VII	2	$y = 40.9 - 0.019\,x$	$r = -0.142$	$y = 8.7 + 0.083\,x$	$r = 0.332$
RRIM 628	VII	1	$y = 34.8 - 0.067\,x$	$r = -0.581$*	$y = -0.8 + 0.074\,x$	$r = 0.299$
RRIM 628	VII	2	$y = 26.7 - 0.015\,x$	$r = -0.070$	$y = -13.9 + 0.112\,x$	$r = 0.289$
RRIM 628	VIII	1	$y = 41.4 - 0.110\,x$	$r = -0.796$**	$y = -22.8 + 0.142\,x$	$r = 0.575$*
RRIM 628	VIII	2	$y = 40.0 - 0.110\,x$	$r = -0.769$**	$y = -35.2 + 0.165\,x$	$r = 0.828$***
RRIM 701	VII	1	$y = 71.1 - 0.171\,x$	$r = -0.717$**	$y = -30.1 + 0.204\,x$	$r = 0.308$

* P = <0.05 ** P = <0.01 *** P = <0.001

TABLE 12. REGRESSIONS OF ESTIMATED INCREMENT IN DRY WEIGHT (KG) ON RESPECTIVELY PERCENTAGE LATE DRIP AND PERCENTAGE DRY RUBBER CONTENT (PANEL B EXPERIMENTS)

Clone	Estate	Year	Regression on late drip ($n = 5$)		Regression on d.r.c. ($n = 5$)	
PB 86	I	1	$y = 41.1 - 0.184\,x$	$r = -0.925$*	$y = -224.1 + 0.722\,x$	$r = +0.630$
PB 86	I	2	$y = 37.0 - 0.089\,x$	$r = -0.791$	$y = -192.0 + 0.595\,x$	$r = +0.952$*
PB 86	I	3	$y = 12.5 - 0.058\,x$	$r = -0.501$	$y = -25.7 + 0.094\,x$	$r = +0.958$*
PB 86	I	4	$y = 25.0 - 0.278\,x$	$r = -0.874$	$y = -11.8 + 0.089\,x$	$r = +0.744$
PB 86	I	5	$y = 32.7 - 0.340\,x$	$r = -0.924$*	$y = -41.8 + 0.168\,x$	$r = +0.796$
PR 107	I	1	$y = 36.9 - 0.144\,x$	$r = -0.971$**	$y = -311.3 + 0.947\,x$	$r = +0.870$
PR 107	I	2	$y = 50.1 - 0.083\,x$	$r = -0.836$	$y = -100.3 + 0.375\,x$	$r = +0.686$
PR 107	I	3	$y = 32.9 + 0.038\,x$	$r = +0.444$	$y = +42.3 - 0.019\,x$	$r = -0.095$
PR 107	I	4	$y = 53.7 - 0.184\,x$	$r = -0.982$**	$y = -23.9 + 0.175\,x$	$r = +0.249$
PR 107	I	5	$y = 57.3 - 0.194\,x$	$r = -0.687$	$y = -69.5 + 0.285\,x$	$r = +0.563$
RRIM 501	I	1	$y = 16.6 - 0.031\,x$	$r = -0.812$	$y = -37.8 + 0.130\,x$	$r = +0.509$
RRIM 501	I	2	$y = 26.8 - 0.029\,x$	$r = -0.605$	$y = +81.0 - 0.159\,x$	$r = -0.355$
PB 5/51	IV	1	$y = 4.1 + 0.096\,x$	$r = +0.652$	$y = -68.5 + 0.224\,x$	$r = +0.838$
PB 5/51	IV	2	$y = 17.2 + 0.030\,x$	$r = +0.169$	$y = -17.4 + 0.091\,x$	$r = +0.830$
PB 5/51	IV	3	$y = 12.6 + 0.270\,x$	$r = +0.255$	$y = -2.9 + 0.039\,x$	$r = +0.779$
PB 5/51	IV	4	$y = 14.0 - 0.141\,x$	$r = -0.763$	$y = -1.5 + 0.034\,x$	$r = +0.764$
PB 5/51	IV	5	$y = 21.0 - 0.632\,x$	$r = -0.773$	$y = 4.1 + 0.033\,x$	$r = +0.333$
PR 107	IV	1	$y = 66.5 - 0.289\,x$	$r = -0.601$	$y = -56.9 + 0.234\,x$	$r = +0.535$
PR 107	IV	2	$y = 59.5 - 0.515\,x$	$r = -0.932$*	$y = +4.3 + 0.061\,x$	$r = +0.240$
PR 107	IV	3	$y = 40.6 - 0.348\,x$	$r = -0.882$	$y = +2.7 + 0.077\,x$	$r = +0.246$
PR 107	IV	4	$y = 30.9 - 0.462\,x$	$r = -0.942$*	$y = -44.0 + 0.169\,x$	$r = +0.480$
PR 107	IV	5	$y = 48.7 - 0.475\,x$	$r = -0.815$	$y = -37.8 + 0.189\,x$	$r = +0.738$
RRIM 513	IV	1	$y = 24.3 - 0.058\,x$	$r = -0.748$	$y = -28.8 + 0.119\,x$	$r = +0.744$
RRIM 513	IV	2	$y = 15.1 - 0.023\,x$	$r = -0.444$	$y = +2.7 + 0.027\,x$	$r = +0.730$
RRIM 513	IV	3	$y = 18.6 - 0.068\,x$	$r = -0.917$*	$y = -13.5 + 0.069\,x$	$r = +0.883$*
RRIM 513	IV	4	$y = 11.4 - 0.034\,x$	$r = -0.601$	$y = -6.8 + 0.041\,x$	$r = +0.725$
RRIM 513	IV	5	$y = 29.3 - 0.145\,x$	$r = -0.929$*	$y = -23.5 + 0.118\,x$	$r = +0.779$

* $P = < 0.05$ ** $P = < 0.01$

TABLE 13. MEAN DIFFERENCES (KG) OF ESTIMATED DRY WEIGHT INCREMENT LESS THAT CALCULATED FROM REGRESSIONS IN TABLES 5 AND 8 (PANEL A EXPERIMENTS, ESTATES I AND II)

Tapping system	Year	No.	On yield (1)	On yield (2)	On percentage late drip (3)	On d.r.c. (4)
S/2 d/2 100%	1	11	+10.1	+ 8.2	−3.5	+2.5
S/2 d/2 100%	2	11	+ 7.4	+ 6.7	−5.4	+2.4
S/2 d/2 100%	3	11	+ 9.7	+ 6.0	−3.0	+1.1
S/2 d/2 100%	4[a]	11	+ 5.8	+ 5.0	−2.3	+2.6
S/2 d/2 100%	5[a]	9	+ 7.5	+ 5.2	−2.2	+4.3
S/2 d/3 67%	1	11	+ 1.9	+ 1.5	−2.2	−0.2
S/2 d/3 67%	2	11	+ 3.7	+ 3.3	−0.5	+0.9
S/2 d/3 67%	3	11	+ 3.7	+ 3.2	−0.9	+1.2
S/2 d/3 67%	4[a]	11	+ 6.4	+ 5.0	+1.0	+2.6
S/2 d/3 67%	5[a]	9	+ 6.6	+ 4.2	+0.7	+2.6
S/2 d/4 50%	1	11	− 1.6	− 1.2	+1.5	−1.2
S/2 d/4 50%	2	11	+ 2.0	+ 1.8	+3.6	+0.1
S/2 d/4 50%	3	11	− 0.9	+ 1.6	+1.3	+0.2
S/2 d/4 50%	4[a]	11	+ 6.6	+ 5.6	+2.2	+1.9
S/2 d/4 50%	5[a]	9	+ 5.7	+ 5.7	+3.9	+1.7
S/R d/4 70%	1	11	− 2.7	− 3.5	−4.1	−8.0
S/5 d/4 70%	2	11	− 0.9	− 0.5	−2.9	−6.2
S/R d/4 70%	3	11	− 1.8	− 2.6	−4.5	−4.6
S/R d/4 70%	4[a]	11	− 4.3	− 5.0	−6.1	−6.2
S/r d/4 70%	5[a]	9	− 4.5	− 5.2	−6.2	−7.7
S/1 d/4 100%	1	11	− 1.3	− 1.6	−1.1	−3.9
S/1 d/4 100%	2	11	− 5.5	− 4.8	−3.0	−6.3
S/1 d/4 100%	3	11	− 6.6	− 6.9	−2.4	−4.2
S/1 d/4 100%	4[a]	11	− 7.0	− 7.7	−2.4	−4.6
S/1 d/4 100%	5[a]	9	−11.1	−10.3	−5.4	−6.4
S/1 d/6 67%	1	11	− 9.4	− 8.7	−2.6	−8.0
S/1 d/6 67%	2	11	− 6.7	− 5.8	+0.8	−6.0
S/1 d/6 67%	3	11	− 8.8	− 7.3	−2.4	−6.8
S/1 d/6 67%	4[a]	11	− 7.9	− 8.4	−2.5	−8.2
S/1 d/6 67%	5[a]	9	− 9.4	− 7.7	−1.3	−9.3
S/2 d/2 9m/12	1	11	+ 5.6	+ 5.6	+0.9	+7.8
S/2 d/2 9m/12	2	11	+ 5.3	+ 4.3	−0.1	+7.7
S/2 d/2 9m/12	3	11	+ 5.9	+ 5.3	+0.3	+5.6
S/2 d/2 9m/12	4[a]	11	+ 5.2	+ 4.9	−0.2	+4.9
S/2 d/2 9m/12	5[a]	9	+ 7.9	+ 6.2	+0.1	+7.0
S/2 d/3 9m/12	1	11	+ 1.1	+ 2.4	+4.9	+7.6
S/2 d/3 9m/12	2	11	+ 3.0	+ 2.3	+4.8	+6.3
S/2 d/3 9m/12	3	11	+ 2.2	+ 4.7	+5.0	+4.4
S/2 d/3 9m/12	4[a]	11	+ 8.5	+ 7.9	+4.9	+6.4
S/2 d/3 9m/12	5[a]	9	+ 9.3	+ 8.5	+6.8	+8.8
S/1 d/3 9m/12	1	11	− 1.6	− 0.6	+1.2	+1.9
S/1 d/3 9m/12	2	11	− 4.1	− 3.9	−0.4	+0.6
S/1 d/3 9m/12	3	11	− 3.6	− 2.7	+1.6	+2.0
S/1 d/3 9m/12	4[a]	11	− 3.1	− 4.0	+1.5	+0.8
S/1 d/3 9m/12	5[a]	9	− 5.0	− 3.1	−0.4	+0.3
S/1 d/4 9m/12	1	11	− 3.1	− 2.0	+4.8	+1.6
S/1 d/4 9m/12	2	11	− 3.7	− 3.4	+3.4	+0.7
S/1 d/4 9m/12	3	11	− 2.7	− 1.5	+5.0	+1.0
S/1 d/4 9m/12	4[a]	11	− 3.5	− 3.8	+3.8	−0.2
S/1 d/4 9m/12	5[a]	9	− 4.2	− 3.4	+4.0	−1.3
Untapped	1	11	+ 0.8	–	–	–
Untapped	2	11	− 0.4	–	–	–
Untapped	3	11	+ 2.9	–	–	–
Tapped S/1 d/4	4[a]	11	− 6.7	–	–	–
Tapped S/1 d/4	5[a]	9	− 2.7	–	–	–
Scalar mean			4.9	4.6	2.7	4.0

(1) From regression of estimated dry weight increment on yield including untapped trees
(2) From regression of estimated dry weight increment on yield excluding untapped trees
(3) From regression of estimated dry weight increment on percentage late drip excluding untapped trees
(4) From regression of estimated dry weight increment on percentage d.r.c. excluding untapped trees
[a]Previously untapped trees tapped S/1 d/4 100%

TABLE 14. MEAN DIFFERENCES (KG) OF OBSERVED ESTIMATED DRY WEIGHT INCREMENT LESS THAT CALCULATED FROM REGRESSIONS IN TABLES 6 AND 11 (FURTHER PANEL A EXPERIMENTS – FIRST GROUP OF SIX EXPERIMENTS)

Tapping system	Year.	On yield (1)	On yield (2)	On percentage late drip (3)	On d.r.c. (4)
S/2 d/2 100%	1	+7.7	+7.5	−5.9	+5.5
S/2 d/2 100%	2	+5.8	+5.7	−5.9	+4.3
S/2 d/3 67%	1	+3.9	+6.1	+1.4	+3.2
S/2 d/3 67%	2	+6.8	+7.3	+6.8	+6.4
S/2 d/4 50%	1	−0.2	+0.5	+4.4	+2.0
S/2 d/4 50%	2	+3.9	+5.6	+10.4	+5.0
S/R d/3 100%	1	+1.1	+0.5	−6.7	−5.1
S/R d/3 100%	2	−2.4	−3.6	−9.8	−7.9
S/R d/4 75%	1	−2.2	−2.3	−2.0	−6.3
S/R d/4 75%	2	0.0	0.0	−2.6	−4.6
2S/2 d/4 100%	1	−1.7	−2.5	−2.2	−7.1
2S/2 d/4 100%	2	−1.8	−2.6	−3.2	−3.0
2S/2 d/6 67%	1	−8.3	−7.7	−2.1	−6.0
2S/2 d/6 67%	2	−6.9	−6.5	−3.4	−6.1
S/1 d/4 100%	1	−2.5	−3.1	−2.7	−6.9
S/1 d/4 100%	2	+6.2	+5.3	+6.1	+5.6
S/1 d/6 67%	1	−7.3	−6.7	−1.5	−6.9
S/1 d/6 67%	2	+5.3	+5.8	+9.0	+4.1
S/2 d/2 9m/12	1	+8.1	+8.5	+1.6	+12.8
S/2 d/2 9m/12	2	−1.8	−1.0	−4.3	−0.1
S/2 d/3 9m/12	1	−0.6	+1.5	+5.0	+6.4
S/2 d/3 9m/12	2	−7.7	−5.9	−1.2	−3.4
S/1 d/3 9m/12	1	+2.1	+1.9	+4.2	+6.0
S/1 d/3 9m/12	2	−5.1	−5.3	−4.8	−0.7
S/1 d/4 9m/12	1	−2.6	−2.2	+6.4	+2.4
S/1 d/4 9m/12	2	−5.1	−4.7	−0.3	+0.6
Untapped	1	+1.4	–	–	–
Untapped	2	+2.8	–	–	–
Scalar meen	–	4.0	4.2	4.4	4.9

(1) From regression of estimated dry weight increment on yield including untapped trees
(2) From regression of estimated dry weight increment on yield excluding untapped trees
(3) From regression of estimated dry weight increment on percentage late drip excluding untapped trees
(4) From regression of estimated dry weight increment on percentage d.r.c. excluding untapped trees

The mean differences are least – irrespective of sign – for those derived from the regressions on late drip in the Panel B experiments [in which there are no periodic systems *(Table 16)*] and greatest in those based on yield. This is so also – but less markedly – in the Panel A experiments on Estates I and II *(Table 13)*. This generalisation does not hold for the further Panel A experiments *(Tables 14* and *15)* in which the selection of tapping systems, especially the periodic systems, seems to have produced some large differences in those derived from the regressions on late drip and d.r.c.

Multiple Regression Analysis of Clonal Trial

The shoot dry weight per tree at opening Fields 48AD ranged from 100.3 kg to 173.2 kg (mean 128.9 kg). The mean yield per tree during the first five years of tapping ranged from 14.0 kg to 35.5 kg (mean 21.4 kg). The estimated increment in shoot dry weight during the same period ranged from 107.6 kg to 285.4 kg (mean 191.5 kg). The trees lost due to storm during this period ranged from 0 to 54 per hectare (mean 12). The plugging indices ranged from 1.80 to 6.15 (mean 3.59).

TABLE 15. MEAN DIFFERENCES (KG) OF OBSERVED ESTIMATED DRY WEIGHT INCREMENT LESS THAT CALCULATED FROM REGRESSIONS IN TABLES 6 AND 11 (FURTHER PANEL A EXPERIMENTS – PB 28/59 AND RRIM 628)

Tapping system	Year	On yield (1)	On yield (2)	On percentage late drip (3)	On d.r.c. (4)
S/2 d/2 100%	1	+5.9	+2.2	−4.8	−1.8
S/2 d/2 100%	2	−1.6	−4.3	−9.0	−7.5
S/2 d/3 67%	1	+1.6	−0.1	−2.1	−2.5
S/2 d/3 67%	2	+3.6	+1.3	−0.1	−0.4
S/2 d/4 50%	1	−2.5	−1.2	+0.4	−1.6
S/2 d/4 50%	2	+2.5	+1.5	+3.5	+2.1
S/2 d/3 (2 × 3d/6)	1	+2.7	+1.3	−0.7	−1.1
S/2 d/3 (2 × 3d/6)	2	+0.4	−0.3	−2.7	−2.8
S/2 d/4 (2 × 4d/8)	1	−4.6	−0.5	−1.4	+1.8
S/2 d/4 (2 × 4d/8)	2	−1.1	+1.0	+0.9	+0.5
S/R d/4 75%	1	−1.5	−3.4	−3.5	−5.8
S/R d/4 75%	2	+1.7	−1.0	−2.2	−3.0
S/R d/6 50%	1	−7.0	−2.6	+0.3	+0.6
S/R d/6 50%	2	−6.7	−2.9	−0.5	−1.0
S/1 d/4 100%	1	−1.2	−3.7	−4.0	−6.5
S/1 d/4 100%	2	−3.8	−2.7	−2.5	−2.8
S/1 d/6 67%	1	−8.1	−5.0	−2.6	−3.1
S/1 d/6 67%	2	−5.4	−3.7	−1.7	−2.3
S/2 d/2 9m/12	1	+4.7	+5.2	+2.6	+5.9
S/2 d/2 9m/12	2	+6.2	+6.6	+4.2	+5.9
S/2 d/3 9m/12	1	+4.0	+6.3	+8.4	+9.1
S/2 d/3 9m/12	2	+1.4	+2.9	+4.7	+5.3
S/1 d/3 9m/12	1	+1.0	+1.2	+3.6	+2.3
S/1 d/3 9m/12	2	−0.6	+1.0	+2.1	+3.0
S/1 d/4 9m/12	1	−1.7	+0.2	+4.1	+2.7
S/1 d/4 9m/12	2	−1.1	+0.6	+3.2	+3.0
Untapped	1	+7.1	–	–	–
Untapped	2	+4.4	–	–	–
Scalar mean	–	3.4	2.4	2.9	3.0

(1) From regression of estimated dry weight increment on yield including untapped trees
(2) From regression of estimated dry weight increment on yield excluding untapped trees
(3) From regression of estimated dry weight increment on percentage late drip excluding untapped trees
(4) From regression of estimated dry weight increment on percentage d.r.c. excluding untapped trees

The total biological yield during the five years of tapping (increment plus 2.25 × yield of rubber) and the efficiency (2.25 × yield of rubber–biological yield) were calculated to find out if they were correlated with weight at opening (a measure of vigour during immaturity) or with the plugging index. However, the variation in both biological yield and efficiency were accounted for very largely by the factors contributing to their calculation, namely increment during tapping for the former and also yield of rubber for the latter. Inclusion of weight at opening or of plugging index in multiple regression analysis accounted for only a little more of the variation in biological yield or efficiency. Weight at opening is correlated with increment during tapping and yield is correlated with both weight at opening and the plugging index.

The correlation matrix of x_1 weight at opening, x_2 yield, x_3 increment in weight during tapping, x_4 trees lost by storm and x_5 plugging index is given in *Table 17* with those multiple correlations which account for significantly more of the variation in variables of interest than the simple correlations. The yield of rubber is correlated

TABLE 16. MEAN DIFFERENCES (KG) OF OBSERVED ESTIMATED DRY WEIGHT INCREMENT LESS THAN CALCULATED FROM REGRESSIONS IN *TABLES 7* AND *12* (PANEL B EXPERIMENTS)

Tapping system	Year	No.	On yield (1)	On percentage late drip (2)	On d.r.c. (3)
S/2 d/2 100%	1	6	+6.3	−2.1	+5.4
S/2 d/2 100%	2	6	+3.9	−0.4	+2.9
S/2 d/2 100%	3	5	+1.5	+0.2	+2.4
S/2 d/2 100%	4	5	+2.0	+0.5	+4.5
S/2 d/2 100%	5	5	+4.5	+3.0	+7.2
S/2 d/3 67%	1	6	+2.7	+1.3	+0.6
S/2 d/3 67%	2	6	+3.4	+1.3	+2.5
S/2 d/3 67%	3	5	+0.6	−1.1	−0.7
S/2 d/3 67%	4	5	+2.1	−0.6	+1.3
S/2 d/3 67%	5	5	−0.4	−3.6	−1.8
S/2 d/4 50%	1	6	+2.2	+4.2	+2.0
S/2 d/4 50%	2	6	+1.1	+0.6	−1.0
S/2 d/4 50%	3	5	+3.5	+1.6	+0.6
S/2 d/4 50%	4	5	+3.8	−0.0	−0.4
S/2 d/4 50%	5	5	+4.1	+1.5	−0.1
S/1 d/4 100%	1	6	−3.3	−2.2	−1.6
S/1 d/4 100%	2	6	−3.3	−0.4	−0.2
S/1 d/4 100%	3	5	−2.4	−0.3	+0.7
S/1 d/4 100%	4	5	−4.4	−0.6	−2.0
S/1 d/4 100%	5	5	−3.6	−1.6	−0.6
S/1 d/6 67%	1	6	−7.8	−1.3	−6.3
S/1 d/6 67%	2	6	−5.2	−1.0	−4.1
S/1 d/6 67%	3	5	−3.1	−0.5	−3.0
S/1 d/6 67%	4	5	−3.5	+0.7	−3.5
S/1 d/6 67%	5	5	−4.6	+0.7	−4.8
Scalar mean	–	–	3.4	1.3	2.4

TABLE 17. CORRELATION MATRIX OF ESTIMATED SHOOT DRY WEIGHT PER TREE AT OPENING (KG), YIELD PER TREE DURING FIRST FIVE YEARS OF TAPPING (KG), ESTIMATED INCREMENT IN SHOOT DRY WEIGHT (KG), NUMBER OF TREES LOST BY STORM (PER HA) DURING THE SAME PERIOD AND THE PLUGGING INDEX FOR THIRTY CLONES IN FIELD 48AD

r (28d.f) =	x_1	x_2	x_3	x_4	x_5
x_1 Wt. opening	–	0.354 N.S.	0.426*	0.187	0.253
x_2 Yield	–	–	0.038	0.345	−0.241
x_3 Wt. increment	–	–	–	−0.111	0.143
x_4 Trees lost	–	–	–	–	−0.462*
x_5 Plugging index	–	–	–	–	–
Yield on wt opening and P I	$R\,x_2 . x_1 x_5$ = 0.492**				
Trees lost on wt opening and Yield	$R\,x_4 . x_1 x_2$ = 0.352				
Trees lost on wt opening and P I	$R\,x_4 . x_1 x_5$ = 0.560**				
Trees lost on yield and P I	$R\,x_4 . x_2 x_5$ = 0.522**				
Trees lost on wt opening, yield and P I	$R\,x_4 . x_1 x_2 x_5$ = 0.571**				

* P = <0.05 ** P = <0.01

positively with the weight at opening (immature vigour) and negatively with the plugging index, the multiple regression on both accounting for more of the variation than either alone. The increment in dry weight during tapping is correlated mainly with the weight at opening. The trees lost by storm are correlated negatively with the plugging index, which accounts for most of the variation, although the addition of either weight at opening or yield or both accounts for somewhat more.

DISCUSSION

The increments in dry weight during the first two years of tapping recorded by TEMPLETON (1969a) and those given in *Tables 1, 2* and *3* are similar for tapped trees, but in the case of untapped trees the increments computed here range from slightly more than the lower values to approximately double the higher values determined by Templeton. This may be due to inherent site differences or to the selection of the better trees in the stand for the tapping experiments, but these explanations do not account for the relative advantage being so marked with the untapped trees in the tapping experiments and not evident for the tapped trees. It is most likely that the untapped trees enjoyed a competitive advantage over adjacent tapped trees in the same stand in the tapping experiments. The tapped and untapped trees sampled by TEMPLETON (1969a) were in separate stands.

Competition between Tapped and Untapped Trees within Experiments

If there is competition between tapped and untapped trees in the same stand, there may be competition between those tapped on different systems. Adjacent trees compete with one another. The question is whether they do so to such a degree in a manner so as to obscure – or more probably to exaggerate – effects due to tapping treatments. The reversal in sign of the coefficients in the regressions of increment on yield (tapped trees only) during the later years of several experiments *(Tables 5* and *7)* suggests that the trees favoured in early competition have overgrown and shaded their neighbours, thereby obtaining a greater share of the sunshine and consequently both growing and yielding more. The regressions of the relative growth rates on yield *(Tables 7, 8* and *9)* might eliminate some effects due to the different sizes of the trees if they received the same intensity of sunshine, but expression as relative growth rates instead of increments could not correct for actual overshading. There is a close correspondence between the regressions of increment and relative growth rate respectively on yield. Therefore, it appears that competition and bias develop progressively throughout the course of the tapping experiments. Caution is necessary in consideration of the later stages when mutual competitive bias between tapping treatments may be operative. Nevertheless, it is legitimate to question how the differences in growth between treatments arise.

Correlation between Yield and Growth

The lack of a clear relationship between mean yield and growth during tapping *between* experiments *(Tables 2, 3* and *4)* is confirmed by the study *between* clones in Fields 48AD *(Table 17)*. *Within* experiments the untapped trees grow more than tapped trees. Moreover, during the early years, there are negative correlations between growth and yield; that is shoot loss is a function of yield within years and experiments. In most cases both the intercepts and the negative regression coefficients are greater when the untapped trees are included, which suggests that tapping in itself may depress growth in addition to the shoot loss proportionate to the diversion of assimilates from accumulation of dry matter into yield.

Effect of Dry Weight Increment on Yield

The heat of combustion of 1.0 kg rubber hydrocarbon is equal to that of 2.25 kg of wood or average dry matter. Therefore, if the partition of assimilates from dry matter to yield of rubber is completely efficient, the regression coefficient for increment in dry weight on yield should be −2.25. The average for the first year of tapping Panel B experiments is only slightly in excess of the expected figure, namely −2.9. The average regression coefficients for the first year of tapping Panel A experiments excluding untapped trees is −8.9. The mean increments and yields of the trees tapped on Panel A are respectively greater and smaller than those for Panel B, but these differences in mean values could be accommodated by greater differences in intercepts if the regression coefficients were constant. The regressions in the two classes of experiments are quite distinct. Some factor associated with tapping in addition to yield itself seems to be involved.

Growth and Properties of Latex

The regressions of increment on late drip are negative with few minor exceptions during both the early and late years of tapping Panels A and B *(Tables 10, 11* and *12).* Poor growth during the early years is associated with a high proportion of late drip, The continuance of this relationship into the later years may be due to the trees tapped on systems producing a large proportion of late drip (during either early or late years) becoming overgrown (as a result of their poor early growth associated with long late drip) and therefore not growing – or yielding – so well during the later years. Their poor performance in later years being due at that stage to competitive effects which have their origin in adverse partition into growth associated with long late drip during the early stages. The negative regression of increment on late drip (that is the positive correlation of shoot loss with late drip) is much more consistent than either the generally positive correlation between yield and late drip in Panel A experiments or the corresponding generally negative correlation for Panel B *(Tables 2, 3* and *4).* The correlations between increments and yield vary as described previously.

The regressions of increments on d.r.c. are positive with few minor exceptions during both early and late years for Panels A and B. The relationship during the later years of tapping may arise in a similar manner to that suggested for late drip. The positive regressions of increment on d.r.c. are also much more consistent than the corresponding correlations between either yield and d.r.c. or increment and yield.

Properties of Latex and Flow Pattern

The percentage of late drip is a measure of the length of flow. There is no late drip recorded if flow does not extend beyond the normal time of latex collection of about 3 h after the average time of tapping (although, sometimes, little more than an hour after tapping the last tree). Hypothetically a large amount of late drip might occur shortly after latex collection or a small amount might be delivered over a long period, but in practice, owing to the range in the period between tapping and collection, the percentage late drip is a function of the period of flow. A low proportion of late drip and a high d.r.c. are characteristics of short-flow (high plugging) systems, which respond to applications of stimulants by prolongation of flow, increase in late drip, decrease in d.r.c. and an increase in yield (WYCHERLEY, 1973). Long-flow (low plugging) systems exhibit a high proportion of late drip and a low d.r.c. Their response to stimulation is usually a somewhat prolonged flow and a further reduction in d.r.c., although the product of total latex harvested and its average d.r.c. do not always show an increase in yield.

A similar generalisation holds true here that lesser increments and greater shoot losses are associated with a large proportion of late drip and low d.r.c., that is with long flow (low plugging) systems and *vice-versa*. The differences between the 'actual' increments (estimated from girths) and those calculated from the regressions on yield, including or excluding untapped trees [*Tables 14, 15* and *16* (left hand columns)] are predominantly negative for long-cut systems and positive for half spiral systems, that is shoot loss is greater than predicted from yield in long-flow systems and *vice-versa*.

No or little deviation might be expected from the increments predicted from independent variables associated with flow patterns such as late drip or d.r.c. However, the inclusion of both continuous and periodic systems in the calculation of the regressions and deviations introduces greater variation. As noted, increments and yields are definite annual figures whether harvest is during part or the whole of the year. The characteristics of flow pattern are not annual figures in the same way if operative for different periods. Despite this there is a tendency for the differences between actual and calculated increments to be less where late drip is the independent variable. These differences (irrespective of sign) would probably be smaller in the Panel A experiments were it not for the positive values in the periodic systems (and hence negative or reduced positive values in the continuous systems) in the case of those derived from the regressions on late drip and d.r.c.

Comparison with Response to Stimulation

Allowing for these effects of periodic *versus* continuous tapping, there are tendencies toward bigger negative differences (even greater shoot loss than predicted) with longer cuts irrespective of whether the regressions on late drip or d.r.c. are used as the basis of prediction. The trends with less frequent tapping are towards positive and negative differences respectively from the regressions on late drip and d.r.c. Late drip increases, d.r.c. falls and the response to stimulation declines with increasing length of cut; whereas with less frequent tapping both late drip and d.r.c. increase, but the response to stimulation is variable (Wycherley 1973). Positive responses in yield to stimulation are associated with high plugging (Milford *et al.*, 1969) or short flow conditions, which are characterised by little late drip and less markedly by high d.r.c. in the control condition prior to stimulation. Favourable partition as indicated by positive differences between actual and calculated increments (or conversely less shoot loss) and response to stimulation vary similarly in relation to tapping system, flow pattern, late drip and d.r.c. Most anomalies are probably due to late drip and d.r.c. being imperfect measures of flow pattern compared, for example, with the plugging index, although that may not be ideal.

Effect of Tapping Systems on Growth and Yield Components

Positive differences (less shoot loss than predicted from regressions) seem to occur under similar conditions as do positive responses to stimulation. In long-cut systems the differences from the regressions on yield are large and negative; the deviations are not so great from the regressions on late drip and d.r.c., but these negative differences are not eliminated completely owing probably to the inadequacies of these variates to characterise flow pattern. Whereas responses in yield to stimulation are variable as the frequency of tapping is reduced, there are opposing trends in the differences between actual and calculated increments for those computed from the regressions on late drip or d.r.c. respectively. Although both late drip and d.r.c. seem to be inadequate descriptions of flow pattern, their corresponding correlations with either increment in dry weight or response to stimulation are opposite in sign.

Variation with Age

The regression coefficients of increment in dry weight on yield fall in successive years of tapping. This may be associated with the corresponding decreases in late drip and increases in d.r.c. as tapping of each panel proceeds, but the improved partition (less shoot loss per unit yield) may be apparent rather than real owing to competion between trees of different treatments. Considering only the first years of tapping each experiment, the average proportion of late drip in the Panel A experiments on Estates I and II is 13.8%, in the further Panel A experiments 17.5% and in the Panel B experiments 13.0%. First year d.r.c. figures are available for the further Panel A and Panel B experiments only; the averages are respectively 34.1% and 36.6%. These comparisons suggest that not only is the period of flow reduced as the tapping cut moves down the panel, but that it is less for Panel B than A, that is it declines with age. There is qualitative agreement with the hypothesis that the pattern of flow changes from long flow (low plugging) to shorter flow (more plugging) with age, as each panel is tapped and with successive panels and that this is associated with more favourable partition. The magnitudes of the differences in late drip and d.r.c. during the first years of tapping Panels A and B is not convincing. Admittedly late drip and d.r.c. are evidently imperfect measures of flow pattern and the use of late drip and d.r.c. – for want of other means to characterise flow in these experiments – may obscure greater real differences in flow pattern. MILFORD *et al.* (1969) found no differences in plugging indices with age and panel greater than those explicable by day to day variation. Their results deny the hypothesis advanced here. Nevertheless there are significant differences in the proportion of late drip between years within experiments and it would be remarkable if they did not indicate real differences in flow pattern and plugging indices.

The general hypothesis emerges that greater shoot loss than the calorific equivalent of the yield is associated with long flow (low plugging). WYCHERLEY (1973) notes that stimulation consistently depresses girthing, even if the response in yield is lacking or negative. The prolongation of flow is the essential response to stimulation, increased yield is not always obtained, but girthing is almost invariably depressed. The comparisons so far are between tapping treatments (including in the last case the application of stimulants). Comparisons can be made between clones tapped S/2.d/2 100% in Fields 48AD *(Table 17)*.

Relationship between Clones

The increment in dry weight during tapping *(x_3)* is correlated with the dry weight at opening *(x_1)*, the other variables account for little more of the variation *(Table 17)*. The yield *(x_2)* is correlated with the weight at opening *(x_1)* and the plugging index *(x_5)*, the regression on both combined is significant. The dry weight at opening is a measure of the vigour of growth during immaturity, which is indicative of the efficiency of assimilation according to WYCHERLEY (1969). The efficiency of assimilation is probably the physiological basis of the correlations with dry weight at opening *(x_1)* of both yield *(x_2)* and increment in dry weight during tapping *(x_3)*, although these latter *(x_2 and x_3)* are not correlated with each other.

The economic value of the stand is its ability to sustain high yield without deterioration of the stand. In some cases the number of trees lost due to storm damage is correlated with the yield per tree (WYCHERLEY, 1969), although in this case their correlation (x_2 and x_4) fails to attain significance [($r = +0.345$ $P<0.1$) *Table 17*]. The negative correlation ($r = -0.462$, $P<0.05$) between trees lost (x_4) and the plugging index (x_5) deserves examination and explanation. WYCHERLEY (1969) elaborated the findings of WYCHERLEY *et al.* (1962) that trunk snap was due to an unbalance between crown and trunk development; losses were associated with an adverse partition of assimilates reducing trunk growth as a result of high yield. The number of trees lost (x_4) by trunk snap during storms in Field 48AD is correlated negatively with the plugging index (x_5) and more of the variation in losses is accounted for if either the dry weight at opening (x_1) or the yield (x_2) or both are further independent variables in multiple correlations (*Table 17*). Although the correlation between losses and yield (x_4 and x_2) is higher than that between losses and dry weight at opening (x_4 and x_1), the multiple regression of losses on dry weight at opening and plugging index ($x_4 . x_5 x_1$) achieves a higher degree of significance than any other including that on yield and plugging index ($x_4 . x_2 x_5$).

Loss of trees in Field 48AD is associated with low plugging index, that is with long flow, which in the tapping experiments is associated with adverse partition or greater shoot loss than predicted from the yield of rubber. Adverse partition associated with long flow is the putative cause of the relative retardation in trunk growth leading to trunk snap. However, without stands of untapped trees for comparison, the shoot loss cannot be determined. The correlation of losses with yield in simple regression may be due primarily to the negative correlation of yield with plugging index, although there is slight evidence from the multiple correlation that higher yields lead to yet greater losses, there being yet more rubber harvested at a cost of adverse partition. The correlation of losses with dry weight at opening in multiple regressions may be due to the more vigorous trees being leafier with larger crowns to catch the wind as suggested by WYCHERLEY (1969).

CONCLUSIONS

Long flow of latex, whether due to tapping system or stimulation or clonal characteristic, seems to lead to adverse partition, the rubber being harvested at a greater cost in accumulation of dry weight by the tree than the calorific equivalent of the rubber. This probably introduces competitive bias into field experiments of 'single-tree-plot' design within a relatively short period; effects seem to be evident after the first year. Larger groups of trees than those of eight or ten per plot, or of ten or twelve, suggested respectively by NARAYANAN *et al.* (1967 and 1972) may be necessary to eliminate this bias in long-term experiments within monoclone plantings. Larger plots are usual practice in large-scale variety trials.

Why long flow should give rise to adverse partition is a matter for conjecture. Moir in discussion of the findings of TEMPLETON (1969a) mentioned that the ATP required for the phosphorylation of mevalonic acid was provided by the breakdown of hexose to pyruvate, but Bonner replied that it was dubious if the overall reaction was completely efficient. BEALING AND CHUA (1972) quote the suggestion by Bealing that the specific precursor of rubber may originate outside the latex vessels, although the last stages of synthesis occur in the latex. They suggest also that excessive tapping (charac) terised by long flow in the early stagesreduces the permeability of the vessel walls to the precursors. Whether this last point is valid or not, they suggest a system in which the generation of ATP may occur outside the vessel and its utilisation may be within the vessel. Long flow might reduce the efficiency of the overall process by interfering with energy transfer. Moreover there are heavy losses of serum solids during intensive tapping and long flow. Some of the serum solids lost, for example organelles, enzymes and nucleic acids, may be involved in energy transfer. The average amounts of serum solids lost during twenty-three months were 7% to 12% of the weight of rubber harvested under six tapping systems ranging from S/2.d/3.67% to S/1.d/1.400% investigated by BEALING AND CHUA (1972). Although intensive exploitation may cause a relatively heavy drain on serum solids for a while, there is no evidence of the massive loss of the substrates of biosynthesis among the serum solids and definitely no such evidence for the conventional tapping systems used in the experiments examined here or for the period of their duration.

The biosynthesis of rubber hydrocarbon by *Hevea* appears to be an irreversible process; isoprene once formed does not seem to be metabolised. Synthesis slows or stops if rubber is not removed by tapping, but there is no evidence that the reaction is reversed despite the high energy content of the hydrocarbon. The products of photosynthesis are metabolised but by different pathways from those of synthesis and the photosynthetic process is in practice an irreversible reaction leading to an energy-rich product. The irreversibility of photosynthesis is conferred through considerable inefficiency in the utilisation of energy (SYBESMA AND RABINOWITCH, 1968). The apparent irreversibility of rubber biosynthesis may also be at the cost of inefficiency in the utilisation and transfer of energy. This conjecture agrees with that concerning the separation of the earlier and later stages of biosynthesis.

Practical Applications

Yield between clones is correlated with immature vigour, the number of latex vessel rows and the plugging index (MILFORD *et al.*, 1969; WYCHERLEY, 1969) and the maximum yields might be obtained by simultaneous positive selection for vigour, numerous latex vessels and long flow. However, the correlation of long flow with adverse partition, retarded growth and trunk snap, indicates that such a procedure is unlikely to realise the highest potential yields over the whole economic life of the stand of trees. Partition has been shown to be heritable by SUBRAMANIAM *et al.* (1971). Partition seems to be associated with flow pattern, which in turn is correlated with the response to stimulation.

Improvements in breeding programmes might continue to select for vigour and numerous latex vessels, but could be redirected towards high plugging, short flow and advantageous partition. ABRAHAM (1970) demonstrated the effectiveness of ethylene-producing stimulants on several clones to prolong flow and to increase yield when desired. Therefore a re-orientated selection programme will co-ordinate with modern methods of exploitation to give a higher degree of control over yield and the security of the stand than possible hitherto.

It may be inferred from YOON (1967) and RUBBER RESEARCH INSTITUTE OF MALAYA (1969b, 1970b) that the reduction in trunk-snap of susceptible clones such as RRIM 501 and RRIM 613 (both have low plugging long flow patterns) by crown-budding may be due partly to improved partition as well as to modified crown form. This implies that the nature of the crown can modify the pattern of latex flow from the trunk. Further investigation is necessary. Confirmation might provide guidance in the selection of crown clones for top working.

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