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Comparison of yields between budgrafts and mother trees in *Hevea brasiliensis* Muell. Arg.

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Abstract

Data available from three experiments conducted during 1939 and 1953 on the dry rubber yield of mother tree genotypes and clones derived from them by bud grafting were analyzed. These experiments comprised of 64 mother genotypes belonging to 23 families. Three to five bud grafted trees have been derived from each of these mother trees within one year and the age difference between the mother trees and clones were about one year. In all three experiments the dry rubber yields in budgrafts from the high yielding mother trees have reduced. The reduction was highest and significant in budgrafts derived from the highest yielding mother trees. On the other hand the yields of the budgrafts from the low yielding mother trees have increased significantly. The percentage deviation of clone yield with respect to the yields of mother trees shows a regular variation in all the three experiments that could not be expected solely due to the stock/scion interaction. But it is most probably a combined effect resulting from the branch characteristics inherited to the budgraft and the stock/scion interactions. This is an indication that the high yields of mother trees are not transferred to the clones through budgrafting and is an important phenomenon that needs further studies.

Key words: budgraft, *Hevea brasiliensis*, mother tree, yield

Introduction

Planting material of rubber (*Hevea*) in early plantations were the seedlings. Reliability of these seedlings with respect to growth, yield and other characteristics, particularly the resistance to diseases was unpredictable. Due to this the technique of budgrafting introduced for rubber in about 1917 has become a routine practice by 1925 (Cramer 1951). This technique not only helped to produce a whole generation arising from one mother tree but also brought uniformity in rubber plantations with respect to growth, yield and secondary characteristics particularly resistance to diseases in aerial parts. Yet the inherent disadvantage of grafting by the introduction of genetically unknown root stocks could not be avoided. Effects of the stock/scion interaction can have adverse influences on both growth and yield in budgrafted rubber. There is a tendency for fast growing

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root stocks to enhance the growth of the scion but not necessarily the yield (Samaranayake 1978, 1979). Certain root stocks reported to have increased the yield of the scion up to 40% (De Silva 1953 a). But this may not happen always. Some rootstocks also have reduced growth and yield in *Hevea* budgrafts (Samaranayake 1978 & 1979). According to Combe and Genner (1977) certain root stock families have shown to enhance the growth and yield of the scion while others have not. Genner (1977) indicates that the uniformity in grafted plants depend on the graft stock family, individuals within the family, the budgraft and the association between stock/bud provided other factors being equal.

Incompatibility is another factor that affects the bud grafts wherever it is practiced particularly in heterografts. Various reasons for defective development of the union, have been discussed for other crops (Simons, 1987; Salvatierra *et al.,* 1999). The extent to which incompatibility affects the growth and yield in rubber is not known. Another important aspect involved in grafting is the dwarfing of the trees imparting the characteristics of a branch to the bud grafted tree. In rubber this can be considered as the most serious draw back as the budgrafted trees will have smaller trunks, thinner bark of a branch and with a low capacity to renew (Dijkman 1951). The effect of these phenomena together with the stock/scion interactions on the growth and yield in rubber is not clearly known. There is no possibility of studying these separately as the direct effect of budgrafting on growth and yield of rubber cannot be separated from the variability among root stocks. Yield that will be obtained from a bud grafted tree is the confounded effect of all these factors.

In a search for information regarding these aspects, past research reports were referred and some valuable data on studies comparing the yield of mother trees and budgrafts derived from them were found. Append below is an analysis of the data from three such experiments verifying the relationship between the yields of mother trees and budgrafts.

Materials and Methods

The data for this analysis comes from experiments conducted by the Botany Department of the Rubber Research Institute of Ceylon (RRIC) during 1939-1954. This is a rare set of results from three experiments where complete yield data for 64 mother trees belonging to 23 families and budgrafts derived from them are available.

Experiment 1

This was an experiment comprising the seedlings of 1939 hand pollination program where complete data for 24 mother trees belonging to 7 families and clones derived from them are available for five years from 1949-1953. The bud grafted trees were planted in 1941 with five trees for each clone in a 7acre (2.83 ha) block in the

Nivitigalakele RRIC sub station. Rainfall in the area in 1953 and 1954 were around 4580 mm and 3747 mm. Tapping of trees has commenced in 1947 with half spiral alternate day system giving a tapping intensity 100%. (Table VB, Annual Report for 1953, pp 42)(De Silva 1953).

Experiment 2

The mother trees in this experiment were derived from the seedlings of the 1944 hand pollination program. A complete set of data for 26 mother trees belonging to four families and their clones planted as three trees per clone were available for three years from 1951-1953. Planting was done in 1944 in a 4.5acre (2.19 ha) plot in Nivitigalakele and the clone WG 6278 has also been allocated to groups of five clones in a balanced incomplete block lay out. Tapping has commenced on 1/2S/D/2 100% system in 1951(Table VII Annual Report 1953, pp 43) (De Silva 1953).

Experiment 3

The other set of data comes from a clone trial in a 14 acre (5.67 ha) block planted in the Hedigalla station of the RRIC with the seedlings of the 1941 hand pollination program. Complete data for 14 mother trees in eight families and their clones are available for three years from 1951. Clones were planted in 1943/1944 and tapped 1/2S/d2 100% commencing from 1950 (Table IXB Annual Report 1953 pp 46) (De Silva 1953).

A pricking method called 'Testatex'(Cramer 1951) has been used for selecting high yielding mother trees within one year after establishment of the hand pollinated seedlings. But the reliability of this method for testing future yields seems to be in doubt due to the younger age of trees and the method itself. Bud wood from these trees has been used to raise bud grafted plants. These mother trees and clones were about seven and six years respectively at the stage of commencement of regular conventional tapping.

Statistical analysis

The percentage deviation of clone yield with respect to its corresponding mother tree yield was computed separately for the three experiments taking all data together for each experiment and for those families with sufficient progenies in each experiment *viz*: RLD 8 × MK 3/2 with12 progenies in experiment 1, RLD 8 × TJ 1 with 11 progenies in experiment 2 and PB 86 × PR 107 with 5 progenies in experiment 3. Clone and mother tree yields were subjected to 't-tests' and were performed taking mother trees into low, medium and high yield categories. Folded F method was used to test the equality of variances. When the variances are equal the 'pooled t' test' was performed and 'Satterthweite' method was employed when the variances are unequal (Genstat, 2001). This test was performed for the first two experiments only as the data in the third experiment was considered insufficient to represent the three yield classes.

Results

Experiment 1

The yield of 24 mother trees in the 7 families in this experiment, except the RLD 8 x MK 3/2 family, cannot be considered family wise as the number of progenies are few. When the mean yield of all mother trees for the five years were considered the yield range was 10.2- 3.2 kg/tree/year with a mean of 5.6kg/tree/year, while the range of yield for their clones was 6.2-4.2 kg/tree/year with a mean of 5.4 kg/tree/year (Table 1). This is due to the reduction of the yields of all high yielding mother trees in their budgrafts and the increase in the yield of low yielding mother genotypes in their bud grafts (Fig. 1). The percentage of budgrafted clones that has given lower yield than the mother genotypes were 45.8 and those yielded more than mother genotypes were 54.2 (Table 1). Even the RLD 8 × MK3/2 family with 12 progenies in this experiment when considered separately shows the same trend and nearly 50% have reduced yields in their budgrafts (Fig. 5).

When the mother trees were grouped into low, medium and high yielding categories and the t' test performed shows that the yields of clones from the low yielding mother tree category were significantly greater than those of mother trees, while the yields of clones of high yielding mother trees were significantly reduced. The yields of clones from moderate yielding mother trees did not show a significant difference (Table 2).

Table 1. *The yield of the highest and lowest yielding mother trees (kg/tree/year) and of clones derived from them, their means and the percentage of trees in clones giving yields lower and higher than the mother tree genotypes in the three experiments. (Figures in parentheses are the number of mother trees in each experiment)*

Experiment	Mother tree		Clone		% lower than mother	% higher than mother
	Yield range	Mean	Yield range	Mean		
1 (24)	10.2-3.2	5.6	6.2-4.2	5.4	45.8	54.2
2 (26)	9.8-2.7	6.2	6.0-3.1	4.4	50.0	50.0
3 (14)	9.3-2.6	5.6	7.7-4.4	5.3	50.0	50.0

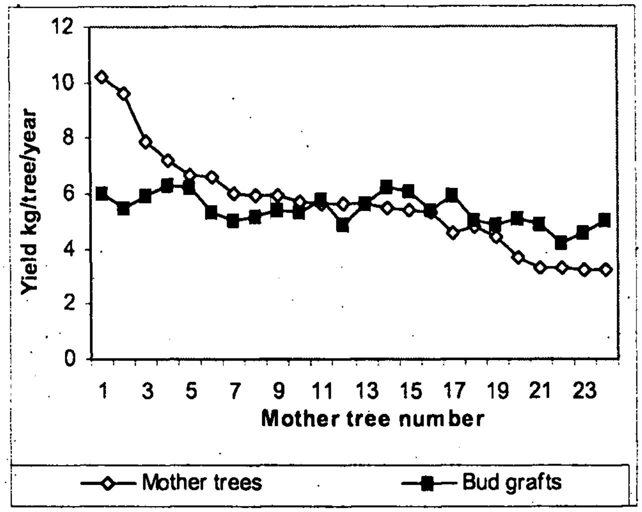

Fig.1. The yield of mother trees in a descending order and the average yield of the respective budgrafts in experiment 1 (mean of 5 years data)

Table 2. *Differences between mother tree yields (kg/tree/year) and their clones, the t' values and probability levels of the three yield categories of mother trees in experiment 1*

Category of mother tree	Yield of mother trees	Yield of clones	t' values and probability levels
Low	3.46	4.67	t = 3.05: p> | t | 0.0086
Medium	5.53	5.09	t= -0.61: p> | t | 0.5564
High	6.16	5.23	t= -3.07: p> | t | 0.0149

Experiment 2

This experiment also showed the same trend (Fig. 2). When all mother trees in the experiment were considered together 50.0% of bud grafted clones derived have given lower yield than their mother trees. The yield range of 9.8-2.7 kg/tree/year in mother genotypes has changed to 6.0-3.1 kg/tree/year in their bud grafts. This means that the yield of 9.8 kg/ha/year in the highest yielding mother trees has reduced to 6.0 kg/tree/year in bud grafts and 2.7 kg/ha/year yield of the lowest yielding mother tree have increased to 3.1 kg/ha/year (Table 1). In this experiment too, when the largest family, RLD8 × TJ1 with 11 progenies was considered the same trend *i.e.* the yields of nearly 50% of clones show lower yields than their mother tree genotypes (Fig 7).

Similar t' test performed for the second experiment as for the 1st show that the yields of clones derived from mother trees of both high and medium categories were significantly reduced in their budgrafts while those of low yielding mother trees have significantly increased (Table 3).

Experiment 3

The trend in this experiment was also same as in the other two experiments. The yield range in mother trees was 9.3-2.6 kg/tree/year and in budgrafts this has changed to 7.7-4.4 kg/tree/year showing a decrease of the 9.3 kg/ha/year of the mother tree to 7.7 kg/ha/year and an increase of the 2.6 kg/ha/year yield of the lowest yielding mother trees to 4.4 kg/ha/year in the budgrafts (Fig 3). The 5.6 kg/tree/year mean of mother tree genotypes has come down to 5.3 kg/tree/year. In this experiment the largest family PB 86 × PR 107 had only five progenies also showed the same trend as in the first two experiments.

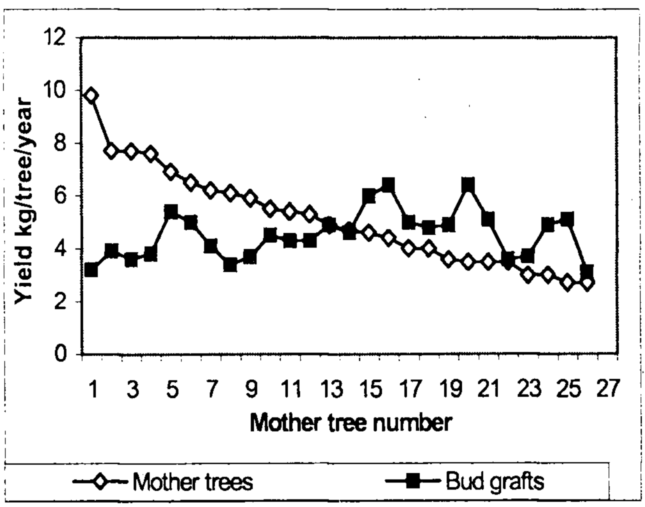

Fig.2. The yield of mother trees in a descending order and the average yield of the respective budgrafts in experiment 2 (mean of three years data)

Table 3. *Differences between mother tree yields (kg/tree/year) and their clones, the t' values and probability levels of the three yield categories of mother trees in experiment 2*

Category of mother tree	Yield of mother trees	Yield of clones	t' values and probability levels
Low	3.19	3.98	t= 3.59: p> |t| 0.0027
Medium	5.40	4.33	t= -3.39: p> |t| 0.0011
High	7.93	4.40	t= -5.24: p> |t| 0.0004

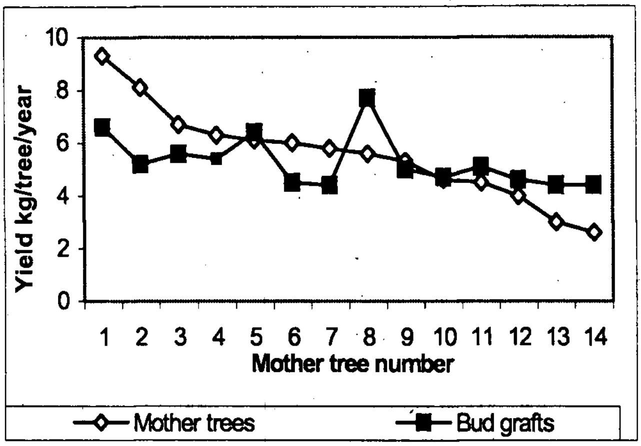

Fig.3. The yield of mother trees in a descending order and the average yield of the respective budgrafts in experiment 3 (mean of three years data)

Figures 4, 6 and 8 illustrates the percentage deviation of clone yield with respect to mother tree yields in experiments 1,2 and 3 respectively and all three shows similar regular relationship. The decrease in yield was greatest in clones derived from highest yielding mother trees while those derived from lowest yielding mother trees have shown a considerable increase. The clones from moderate yielding mother trees have given comparable yields as their mother trees. Percentage deviation derived for the largest families in the three experiments *viz:* RLD 8 × MK 3/2 in expt.1, RLD 8 × TJ 1 in expt. 2 and PB 86 × PR 107 in expt. 3 where sufficient progenies were available for consideration also show the same trend (Figs.5,7 and 9).

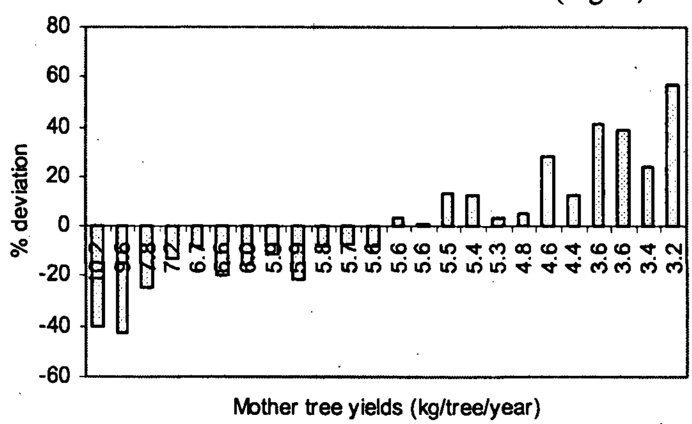

Fig 4. Percentage deviation of clone yield with respect to mother tree yields in experiment 1

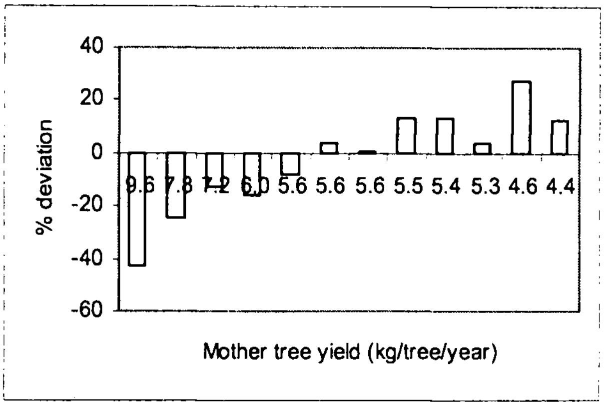

Fig 5. Percentage deviation of clone yield with respect to mother tree yields in the RLD 8 × MK3/2 family with 12 progenies in experiment 1

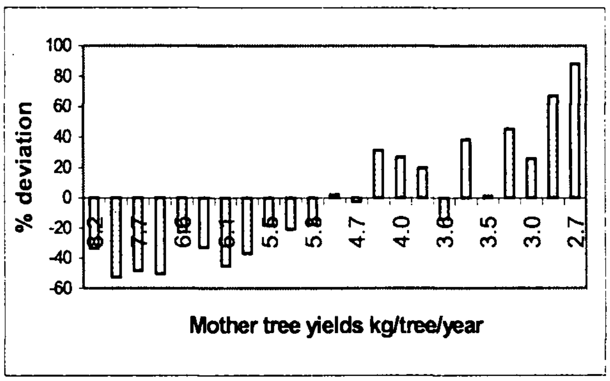

Fig 6. Percentage deviation of clone yield with respect to mother tree yields in experiment 2

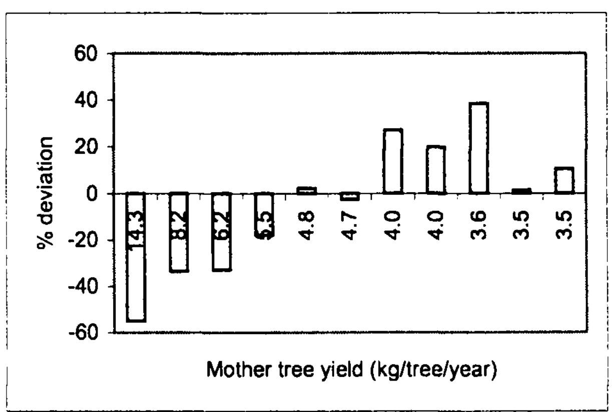

Fig 7. Percentage deviation of clone yield with respect to mother tree yields in the RLD 8 × TJ1 family with 11 progenies in experiment 2

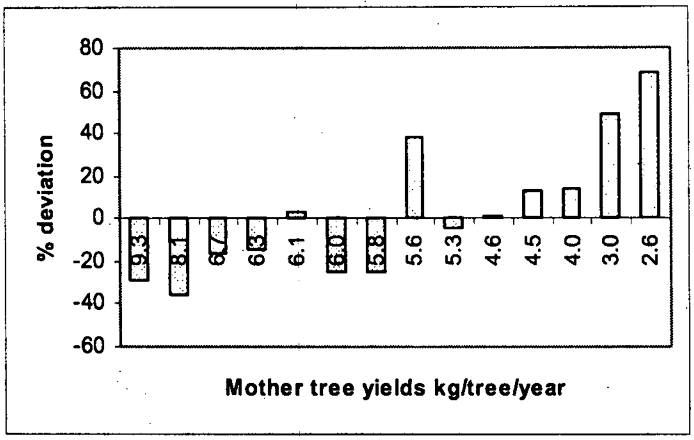

Fig 8. Percentage deviation of clone yield with respect to mother tree yields in experiment 3

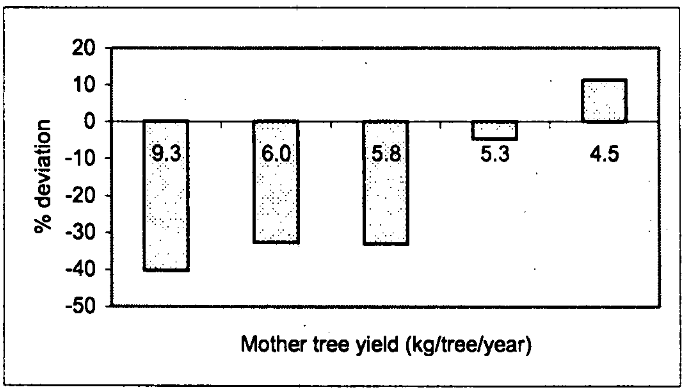

Fig 9. Percentage deviation of clone yield with respect to mother tree yields in the PB 86 × PR 107 family with 5 progenies in experiment 3

Discussion

Data presented here comes from three experiments involving 64 mother tree genotypes in 23 families and 260 budgraft trees derived from these mother genotypes. In all these experiments a single mother tree has been compared with 3-5 budgrafted trees and cannot be considered as sufficient for a sound experiment. This is always the situation where parents used are not from clone origin. It is also important to consider that the 260 bud grafted trees carry an equal number of unknown seedlings as root stocks. This is also a complication in this type of experiments.

Testing of seedlings from hand pollinated seeds was done within one year and bud grafts generated from them also have been planted within one year. The value of this set of data lies on several facts. In both clones and mother trees, tapping has commenced in the same year and the difference in age between the mother trees and the budgrafts were only one year. The availability of yield data of the clones and mother trees for five years in experiment 1 and three years for experiments 2 and 3 was also an advantage.

Each and every root stock in budgrafts is an unknown genotype. They influence differently on the scion and can only bring about a common effect. Some vigorous root stocks tends to improve the growth of the scion (Gener 1977, Samaranayake, 1978) and the yields of the scion can also be improved due to the influence of the root stock (Combe and Gener 1977). Stock scion effect is an interaction that can be very variable depending on the genotypes of both scion and stock. Compatibility between the two also has its influence but the extent of this is not clearly known. The scion in incompatible combinations may not grow or will have very poor growth (Simons 1987). The dwarfing effect is common to all budgrafts reducing the size of the tree and acquiring the characteristics of a branch of a tree affecting the yield and growth of rubber trees (Dijkman, 1951).

The outcome in this analysis however cannot be explained by only taking the above factors into consideration. The important indication in this data is the difference of the yields of the mother trees and their budgrafts. All three experiments show the same trend. The 't' test performed in experiments one and two shows significant differences between mother tree yield and the yields of the corresponding clones indicating the large reduction in the yields particularly of high yielding mother trees in their clones. The increase in yield of clones derived from low yielding mother trees was also significant in the 1st two experiments. This cannot be due to the age difference between the mother trees and the clones. One year age difference cannot make such a marked difference that prevailed through 3-5 years. This has resulted in the reduction of variability in clones with regard to yield compared to mother trees.

The percentage deviation of yields of budgrafts with respect to mother tree yields when all mother trees were considered together in each experiment and also within families do not show that this is a phenomenon of random occurrence which can be the case with stock/scion interactions. It is obviously the effect of budgrafting. Ferwerda (1940, quoted by Dijkman 1951) has reported that 26% budgrafts yielded as much as or more than their mother trees. The remaining 74% yielded less. Further on grouping these budgrafts into low and high yielding classes, it has been found the budgrafts that yielded as much as or more than their mother trees have come from the lowest yielding seedling classes. On the other hand the yields of budgrafts from the two highest yielding mother tree classes have remained below that of mother trees. The above finding exactly agrees with the revelation in this investigation which also has been noted by De Silva (1953).

The phenomenon represented here is most probably the characteristics of a tree that was generated from an axillary bud in budgrafts and appears that it also represent the distinction between the dry rubber yields of the trunk of a mother tree and a branch. It may be possible that the effects of budgrafting have become very prominent masking any stock/scion effects and can reasonably be assumed that the contribution by root stock/scion interaction to the differences observed here between seedling mother trees and their clones can be minimal.

This data, as well as those in many other records show that there have been very high yielding seedlings withstanding 1/2S/d2 100% tapping for many years (Cramer 1951, De Silva 1953). In this study it appears that high yields of seedlings have not been transferred to grafted clones. Further studies are needed to arrive at firm conclusions.

Acknowledgement

The data used here have come from experiments conducted in the Botany Department of the Rubber Research Institute of Ceylon during 1939 and 1953 by Mr C A de Silva who served during 1935 and 1965 as a Botanist and as the first Ceylonese Director. It is opportune to appreciate and place a mark of tribute to his dedication and invaluable contributions to the rubber industry.

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