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YIELD DECLINE IN *HEVEA* TREES: A COMPARATIVE EVALUATION OF SIXTEEN YEARS LATEX YIELD

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Yield of rubber tree varies over the years depending on many biological, environmental and management factors. In an experiment, the latex yield of 12 *Hevea* clones was monitored for 16 years under S/2 d2 6 d/7 system of tapping. The yield increased gradually in initial years of tapping and maintained a higher yield output from 3rd to 15th year. Yielding pattern of rubber trees varied among the clones. Clone PB 235 and RRII 118 showed a long duration of higher yield output for 15 years. Clones RRII 300, RRII 105, RRIM 501 and PR 107 exhibited higher yield output for 8 to 10 years. After a specific period of vigorous latex output, the yield started declining in all clones. The onset of yield decline was different among the clones and it varied from 11th to 16th year of tapping. In clones RRII 105 and RRIM 703, the yield decline commenced from 12th year of tapping, whereas this was between 15th to 16th year of tapping in clones PB 235, RRII 118, RRIM 600, GT1 and Gl 1. Generally, a drastic reduction in yield was observed after 16 years of tapping when the trees were 23 years old. Clones RRIM 703 and RRIM 501 showed the highest decline (40%) from peak yield at 16th year of tapping. The popular clone RRII 105 recorded around 20 per cent decline. This was almost negligible in clones RRII 118 and Gl 1. The decline in yield of rubber trees could be attributed to ageing, soil fertility, environmental and agro-management factors that might reduce the tree growth and shorten the economic life span of trees.

Keywords: Latex yield, Peak yield, Yield decline

INTRODUCTION

Hevea brasiliensis, a perennial tree crop attain tappability and become economically significant in six to seven years after planting and reaches full production potential in three to four years of tapping. After a period of vigorous latex output the productivity drastically declines, thereafter the trees are cut down from the plantations and are usually replanted with new clones. The yield per tree per tap increases with increase in girth of trees due to the increase in length of tapping cut (Dijkman, 1951; Karunaratnel *et al.*, 2005). However, the growth of rubber trees tends to decline gradually during the later period. Moreover, the productivity of rubber tree is determined not only by its inherent genetic factors but also prevailing environmental conditions. Tree to tree variation and

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seasonal variation in yield is a common occurrence in rubber plantations (Chandrashekar *et al.*, 1990; Marattukalam *et al.*, 2006; Buttery, 1961; Sreelatha *et al.*, 2007).

Ageing related decline of growth and productivity in rubber tree is a complex phenomenon. Rubber can be grown in field up to 60 years or more and the yield declines to the level of almost to nil at an age of approximately 50 years (Smith and Burger, 1992). Rubber trees are prone to wind damage, a variety of diseases including tapping panel dryness and reduction in size of canopy are other major possible causes that increased with the age of plantation resulting in declining productivity. Thus the tree suffers a reduction in latex production, making further tapping of the trees uneconomic after a specific period of latex output. The aim of this study was to determine the duration of peak latex yield and period of yield decline in 12 rubber clones.

MATERIALS AND METHODS

The study was conducted at Central Experiment Station of Rubber Research Institute of India at Chethackal, Kerala. Twelve clones were planted in the year 1982 in two replications and the clones included were RRII 300, RRII 105, RRIM 600, RRIM 612, RRIM 703, RRIM 501, PB 235, PB 86, GT 1, Gl 1, PR 107 and Tjir 1 raised from clonal bud grafts. Trees were opened for tapping at 125 cm height from the bud union. Trees were continuously tapped for 16 years under S/2 d2 6d/7 system of tapping in panels BO-1, BO-2 (virgin panels), BI-1 and BI-2 (renewed panels). Rubber yield was recorded fortnightly by collecting the cup lumps by acid coagulation method. Actual rubber yield was determined by smoke drying of fresh cup lumps deducting a standard 10 per cent moisture content. Annual mean (mean yield of twelve months tapping) and grand mean (mean yield of 16 years tapping) were determined for all clones. The period of yield output showing mean yield or above was considered as peak yielding period of a clone. The yield of a clone was expressed in gram per tree per tap (g t^{-1} t^{-1}). To estimate yield decline in clones the percentage decrease from mean yield was considered. Thus the yield declining phase was identified for each clone that was subjected to tapping for 16 years.

RESULTS AND DISCUSSION

Rubber yield was considerably low in the initial three years from opening of trees for tapping in all clones. The highest yield (33.8 g t^{-1} t^{-1}) was recorded in clone PB 235. All other clones recorded yield in the range of 18 to 30 g t^{-1} t^{-1}. Thereafter a steady increase in latex output was noticed in subsequent years and yield had stabilized in 3 to 4 years of tapping (Fig. 1 A). The yield data of all clones pooled together for 16 years exhibited a typical yield curve for *Hevea* as shown in Figure 1 B. The yield trend exhibited a characteristic low output in initial years followed by an increase from 4 to 5 years and raised to a plateau till 10 to 12 years of tapping followed by a gradual decline thereafter.

Peak yielding phase

Based on per tree yield the clones were broadly categorized as high yielders > 40 g t^{-1} t^{-1} *viz.*, RRII 105, PB 235, RRIM 600, low yielders < 30 g t^{-1} t^{-1} *viz.*, PR 107, RRIM 612 and medium yielders (yield between 30 - 40 g t^{-1} t^{-1}) *viz.*, RRII 118, RRII 300, RRIM 703, RRIM 501, GT1, Gl1 and Tjir 1. Clones RRII 105 and PB 235 were the top most yielders (Fig. 3 A

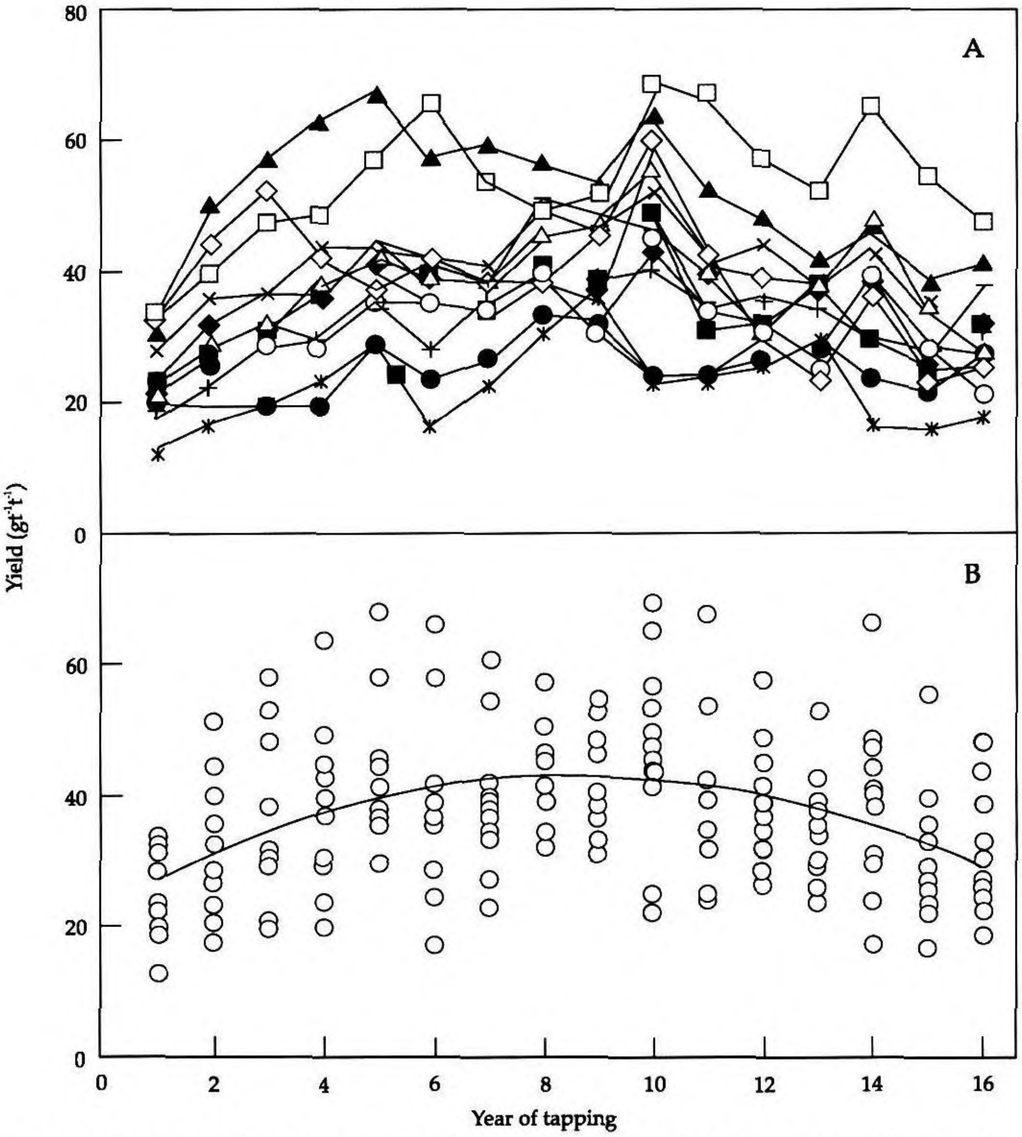

Fig. 1. A. Annual mean yield of 12 *Hevea* clones for 16 years tapping; B. Yield trend of *Hevea* clones for 16 year tapping period.

and 3B). The yield curves for all 12 clones are shown in Figures 2 A and 2 B. In general, the period of peak yield in clones ranged between 2nd and 15th year of tapping and the majority of clones exhibited a good yield trend from 4th to 13th year of tapping (Table 1). Clones PB 235, RRII 118, and RRIM 600 maintained higher yield output for 11 years. Clones RRIM 501, RRII 300 and Tjir 1 recorded higher yield output for 7 to 8 years.

Among the clones, clone PB 235 a high girth and high biomass tree maintained a long duration of higher yield out put up to 15 years of tapping. Clone PB 235 was identified as a high metabolic clone with vigorous growth potential (Lacrotte *et al.*, 2004). In most of the clones considerable reduction in yield was noticed at 16th year of tapping.

Yield decline phase

The yield decline was evident in most of the clones after a period of vigorous latex output and the reduction from mean yield was up to 31 per cent in few clones (Table 2). The popular clone RRII 105 recorded around 20 per cent decline. However, it was up to 30 to 40 per cent from peak yield in many clones.

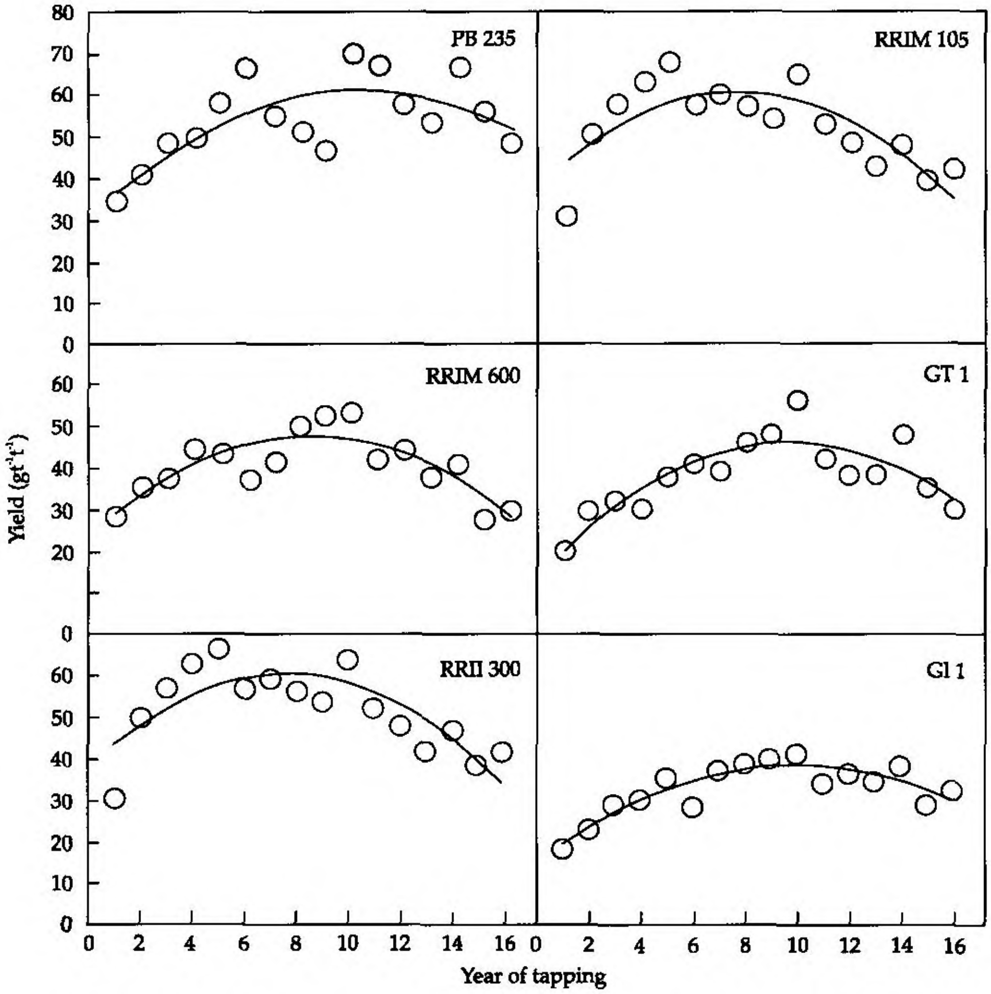

Fig. 2. A. The yield curves of clones PB 235, RRII 105, RRIM 600, GT 1, RRII 300 and Gl 1

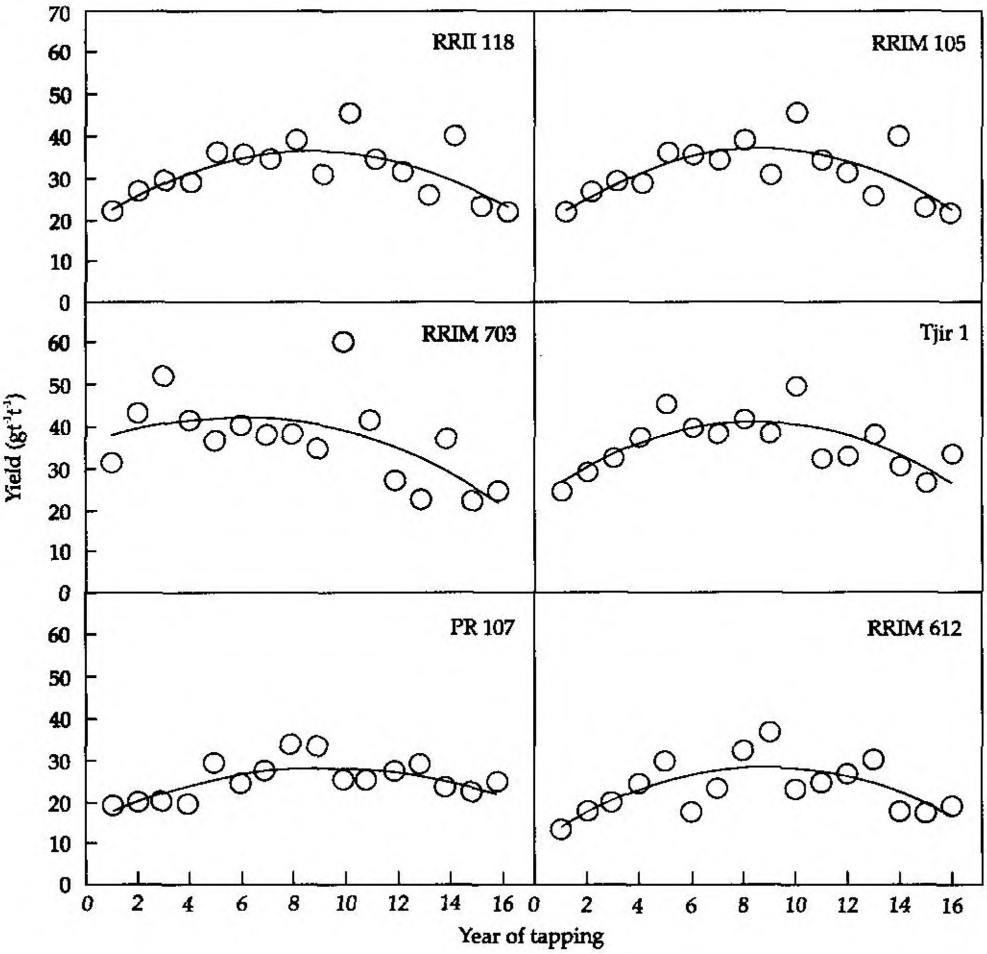

Fig. 2 B. The yield trend curves of clones RRII 118, RRIM 501, RRIM 703, Tjir 1, PR 107 and RRIM 612

The highest decline in yield was noticed in clone RRIM 703. However, it was almost negligible in clones RRII 118 and Gl 1. The yield declining phase in *Hevea* varied from 11[th] to 16[th] year of tapping among the clones (Table 1). In clones RRII 300 and Tjir 1 the yield decline commenced much earlier (from 11[th] year on wards) compared to the high yielding clone RRII 105 (the decline started from 12[th] year onwards). In clone PB 235 the high yield out put was up to 15 years and decline started from 16[th] year onwards. The mean peak yielding period of *Hevea* was from 4[th] to13[th] year and declining phase started from 14[th] year when the trees had reached 22 years age in field. Our long term observation of yield trend in twelve clones indicated the different pattern of yield phases among the clones. On the basis of yield pattern the clones were categorized as

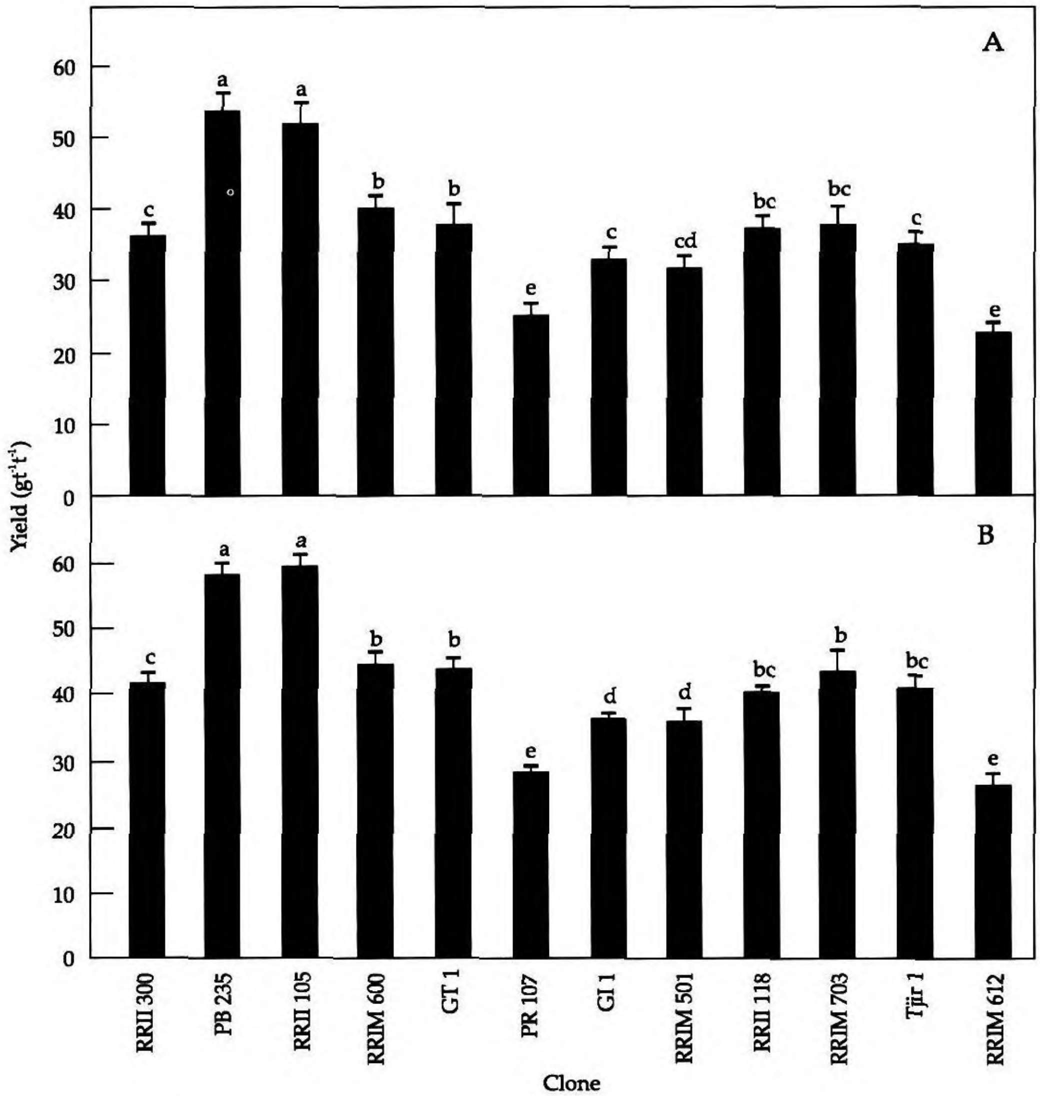

Fig. 3 A. The mean yield B. Peak yield of twelve Hevea clones in sixteen years.

long duration peak yielding clones (LD clones) and short duration peak yielding clones (SD clones). Thus all clones evaluated were grouped in to two major categories for better understanding of clonal behavior in long term yield (Table 3). Thus clones PB 235, RRII 118, Gl 1, GT 1 and RRIM 600 belong to LD category whereas, clones RRII 105, Tjir 1, PR 107, RRIM 703, RRIM 612 RRIM 501 and RRIM 300 come under SD category.

The total rubber production depends on clone, number of trees tapped, agro-

Table 1. **Yield pattern of *Hevea* clones based on peak yield and yield decline with respect to age of trees (years)**

Clone	Tapping period	Peak yielding period	Peak yielding phase	Yield decline phase	Peak yield span of trees (age)
RRII 300	16	8	3 -10	11	19
PB 235	16	11	5 -15	16	24
RRII 105	16	9	3 -11	12	20
RRIM 600	16	11	4 -14	15	23
GT 1	16	10	5 -14	15	23
PR 107	16	9	5 -13	14	22
GI 1	16	10	5 -14	15	23
RRIM 501	16	8	5 -12	13	21
RRII 118	16	11	4 -14	15	23
RRIM 703	16	10	2 -11	12	20
Tjir 1	16	7	4 -10	11	19
RRIM 612	16	10	4 -13	14	22

management practices and prevailing climatic conditions of a locality. Tree to tree variation in yield was prominent in rubber plantations. This might be due to variations in soil factors, genotypic and stock-scion influence (Sobhana, 1998). George *et al.* (1988) estimated the highest yielding period for *Hevea* clones as between 10 to 15 years of tapping and the same yield was not observed in subsequent years. Our results showed that peak yielding phase differed among the clones. The duration of peak yield and the year of decline were also not uniform. In a few clones the yield decline started from tenth year of tapping when the trees were only 18 years old. In majority of clones the economic span of higher yield out put was before the trees attain 20 years old.

Table 2. **Clonal variations in percentage reduction of yield in *Hevea* clones.**

Clone	Per cent reduction from mean yield	Per cent reduction from peak yield
RRII 300	25.8	35.82
PB 235	11.7	18.70
RRII 105	20.0	30.01
RRIM 600	26.3	32.80
GT 1	22.1	31.58
PR 107	4.7	14.31
GI 1	0.6	10.08
RRIM 501	31.4	39.63
RRII 118	0.0	4.33
RRIM 703	31.3	40.72
Tjir 1	6.8	20.53
RRIM 612	19.8	30.63

Dimensions of yield decline in trees are very complex as ageing and productivity of a long duration crop like *Hevea* is concerned. Considering the maximum (theoretical) yield potential of 9500 kg rubber per hectare (Templeton, 1969; Sethuraj, 1981) and the economic yield span of 25 years, there is a concern which on long term yield evaluation indicated an early decline of yield in many clones. A number of biotic as well as abiotic factors might exert considerable impact on growth and latex yield in a long run. A

Table 3. **Classification of clones based on the duration of peak yield, L/S (long duration peak yielder/ short duration peak yielder)**

Clone	Classes	Tapping year for stimulation
RRII 300	S	11
PB 235	L	16
RRII 105	S	12
RRIM 600	L	15
GT 1	L	15
PR 107	S	14
Gl 1	L	15
RRIM 501	S	13
RRII 118	L	15
RRIM 703	S	12
Tjir 1	S	11
RRIM 612	S	14

reduction in latex yield could be attributed to various factors *viz.* changes in canopy density and dimensions, lower leaf area index and decline of biological activity *etc.* (Aweto, 1987; Gilot *et al.*, 1995) as the canopy density and net carbon assimilation have significant role on latex yield in rubber (Yeang and Paranjothy, 1982). Templeton (1968) highlighted gradual decline in growth at later stages due to changes in net assimilation and leaf area ratio. In addition, latex production in *Hevea* is also highly depended on partitioning efficiency of the trees (Samsuddin *et al.*, 1987). The partitioning of photosynthates into biomass and rubber particle is a genetic character of clones. The sustainable rubber biosynthetic potential and flow rate are also clonal character (Samsuddin, 1978; Samsuddin *et al.*, 1987). Rubber plantation depletes soil nutrients as a result of vigorous nutrient uptake, subsequent conversion in to biomass and rubber hydrocarbon and nutrient loss from tapped trees *via.*, prolonged latex output (Annamalainathan *et al.*, 2013). Further the nutrient availability depends on many factors such as soil temperature, texture, pH, organic carbon and moisture contents (Agbenin and Tiessen, 1994; Sanchez, 1976). All such factors influence the root system and in particular root longevity depends on inherent capacity of plant to sustain root biomass with increase in age of trees (Psarras *et al.*, 2000; Marshall and Waring, 1985). The early decline in rubber yield of *Hevea* trees might be the result of cumulative impact of multiple factors prevailing in field.

CONCLUSION

In general the economic life span of rubber tree is 25 years. Rubber yield was low in early years of tapping followed by a steady increase in yield output up to a period of 10 to 15 years. After the prolonged vigorous latex output for a period between 4^{th} and 13^{th} year of tapping the trees showed a declining trend in yield at the age of 20 to 22 years. Other than genotypic reasons it could also be due to the deteriorating soil and environmental factors as well as agro-management practices that reduced the photosynthetic capacity of trees over the years which exhibited significant impact on decline of productivity in *Hevea.* Adopting organic farming practices in rubber plantations together with location specific modern clones is needed to sustain a long economic yield span in rubber trees.

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