YIELD FATIGUE IN *HEVEA* CLONES: AN ASSESSMENT OF DECADAL TRENDS IN COMMERCIAL YIELD OF SELECTED CLONES IN THE TRADITIONAL REGIONS OF INDIA

Binni Chandy and K. Tharian George

Rubber Research Institute of India, Kottayam- 686 009, Kerala, India.

Received: 16 January 2015 Accepted: 15 May 2015

Chandy, B. and George, T.K. (2015). Yield fatigue in *Hevea* clones: An assessment of decadal trends in commercial yield of selected clones in the traditional regions of India. *Rubber Science*, **28**(2): 173-177.

This paper is a preliminary attempt to understand the decadal trends in the yield of selected *Hevea* clones in the traditional regions based on time series data on commercial yield of three popular clones *viz.*, GT 1, RRIM 600 and RRII 105, from the organized large estates. The trends in average yield (kg ha^{-1}) of the three clones for the first 10 years of tapping during different decades was assessed and inter- decadal growth rates in yield were estimated. Trends in other yield related variables *viz*., planting density and tapping systems followed were also considered. The analysis revealed a steady decline in the ten year average yield of clones planted during different decades, except an aberration in the case of RRIM 600 during the 1970s. Although the decadal trends in yield fatigue has been reversed to certain extent by the higher yield of high yielding (HY) clones like RRII 105, the trends in yield of the same underline the inherent limitations. The observed changes in planting density and tapping systems are not expected to be yield depressing. Hence, the observed yield fatigue are construed to be the cumulative effect of depleting soil organic content and fertility as well as climate change.

Keywords: Decadal trends, *Hevea* clones, Traditional region, Yield fatigue

The achievements of India's rubber plantation industry in production and productivity of natural rubber (NR) over the past one century had been commendable for the unique policy interventions and the outcomes. In retrospect, three cardinal elements in India's widely acknowledged achievements in the production sector had been: (i) proactive institutional interventions from propagation of planting materials to marketing of rubber; (ii) a highly receptive farming community; and (iii) the successful adoption of high yielding clones and improved agro-management practices. The evolution of the NR sector under various socio-economic, political, technological and institutional contexts had been well documented (George, *et al*., 1988a; Burger, *et al*., 1995; George, 1999). The popularization of high yielding (HY) clones of planting materials played a pivotal role among the different schemes launched for enhancing productivity and production since independence (George, *et al*., 1988b). The transformation from the use of unselected seedlings with an average yield of above

Correspondence: Binni Chandy (Email: binni@rubberboard.org.in)

300 kg ha^{-1} during the initial phases of plantation (Sarma, 1947) to HY clones with a production potential of around 4000 kg ha^{-1} (Saraswathyamma, 2003) was the result of crop improvement programmes which were initiated in India in 1954 just before the inception of the Rubber Research Institute of India. The subsequent increase in yield potential achieved by genetic improvement has also been widely acknowledged and well documented (Licy *et al*., 1997; Saraswathyamma, 2003). However, there is an explicit vacuum of scientific investigations on the deceleration of growth in productivity and production in recent years except the adverse impact of the growing area under the senile trees (Jacob and George, 2008). While the adverse age-composition has macro level impacts on the performance of NR sector in India the yield fatigue of popular clones is basically a regional issue due to the differences in the planting cycles between the traditional and non-traditional regions. Though the issue of yield fatigue of popular clones is increasingly recognized the empirical evidences to prove or disapprove the same are absent. There are reports on the depleting soil organic content and fertility due to unabated cultivation of NR (Karthikakuttyamma, 1995; Ulaganathan, *et al*., 2010) during the past four generations and the implications of the same on the yield potential (Chan *et al*., 1974). Apparently, non-availability of reliable data on inter-generational trends in yield of popular clones is the reason for the absence of systematic investigations on the issue. The gravity of the issue stems from the combined share of Kerala and Tamil Nadu in India's total area (76.1%) and production (91.2%). From a national perspective, an important development in the recent past has been the demotion of India's status in world NR productivity and production to the third and fifth positions respectively (ANRPC, 2014; IRSG, 2014).

This paper is conceived to analyse the decadal trends in yield of selected rubber clones in the estate sector located in Kerala and Tamil Nadu in order to set the agenda for detailed investigations on the theme with the following:

i) To analyse the trends in yield performance of selected *Hevea* clones in the traditional regions over decades to understand the extent of yield fatigue, if any;

ii) To examine the decadal trends in planting density and tapping intensities of the selected clones and influence of the same on realized yield.

The only source of documented information pertaining to time series data on yield related aspects is in the organized large estates. In the traditional rubber growing regions of Kerala and Tamil Nadu, the existing plantations are beyond the third cycle of planting. Accordingly, the analysis was based on documented database (RRII, 2014) on commercial yield received from 29 large estates in the organized sector covering an area of 4242 ha. Though the estate sector occupies only 10 per cent of the total rubber planted area and seven per cent of the total NR production in India, the study is confined to the sector for two important reasons: (i) reliability of systematically documented information on yield and (ii) being the pioneers, the large estates had more planting cycles with comparable management practices. The participating estates submit a monthly return in a specified format with field-wise information on yield and yield related variables. The three popular clones in the estate sector for which time series data was available *viz*., GT 1, RRIM 600 and RRII 105, were selected for the analysis. Comparable data was available for four decades for clone GT 1 (1960s to

1990s) and three decades each for RRIM 600 (1960 to 1980) and RRII 105 (1970 to 1990s). The decadal trends in average yield (kg ha^{-1}) of trees planted during each decade for the three clones in the first 10 years of tapping was assessed and inter-decadal growth rates were estimated. Trends in other variables influencing yield *viz*., the planting density and tapping systems followed were also considered to understand the potential influence on yield performance. The tapping system followed is denoted by relative intensity expressed as percentage of the standard system *ie*., the alternate daily tapping (S/2 d2), the intensity of which is considered as 100 per cent.

Comparison of the yield performance of clones planted during different decades revealed a steady decline in the ten year average yield for clones GT 1 and RRII 105 whereas after a better performance of trees planted during 1970s the average yield of RRIM 600 also followed suit. The average yield of GT 1 for the first 10 years of tapping declined from 1486 kg ha^{-1} (1960s) to 1235 kg ha^{-1} (1990s) showing a decline of 251 kg ha^{-1} over the four decades (Fig. 1). The decadal average yield of RRIM 600 also declined from 1277 kg ha^{-1} during 1960s to 1194 kg ha^{-1} during 1980s despite a surge the yield during the 1970s. A steady decline in the 10 year average yield was also observed for clone RRII 105 and from 1970s to 1990s the yield declined from 1688 kg ha^{-1} to 1377 kg ha^{-1}, showing a decline of 311 kg ha^{-1} over the three decades. The steepest fall in decadal average yield was recorded in the case of RRII 105 (18.42%) between the 1970s and 1990s.

The analysis of decadal trends in yield has also revealed the valuable contributions of genetic improvement in sustaining the tempo of growth in yield. More precisely, it is illustrative of the feasibility of policy option for addressing the intra-clonal yield

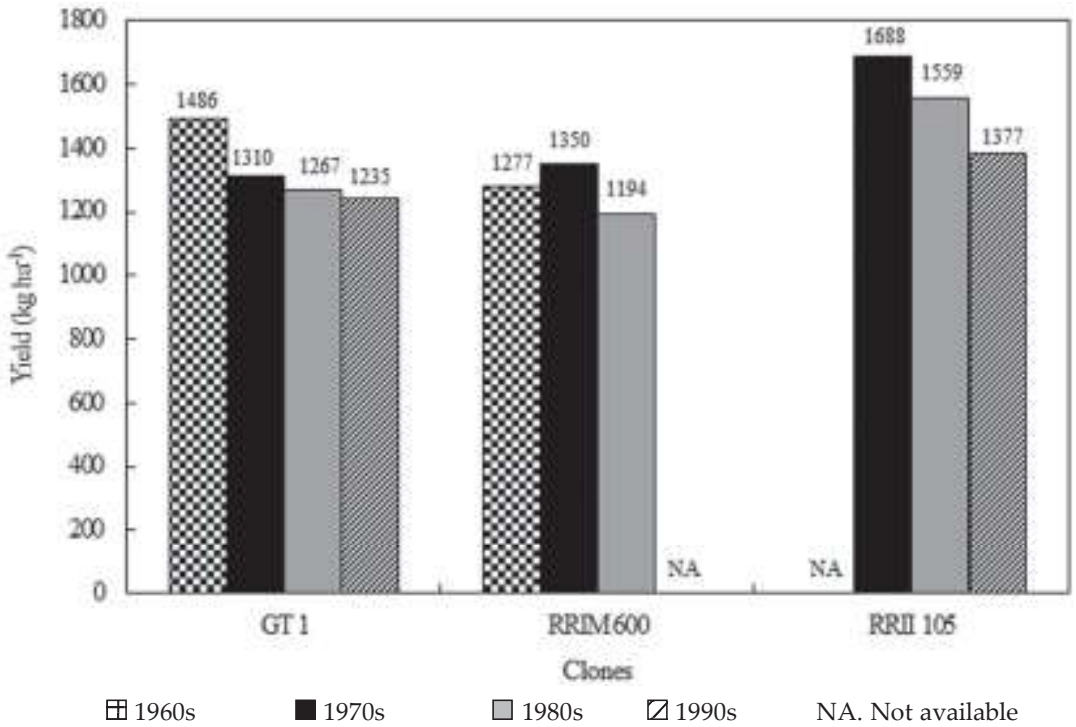

Fig. 1. Average yield (kg ha^{-1}) of clones planted during different decades

fatigue through the introduction of HY clones. This proposition is amply illustrated by the point that even the lowest yield realized by RRII 105 planted during the 1990s (1377 kg ha^{-1}) was higher than the highest yield realized by RRIM 600 planted during the 1970s and GT 1 planted since the 1970s (Fig. 1). Even with a steep decline in yield across decades, the average yield of RRII 105 during the 1990s was higher by 142 kg ha^{-1} compared to GT 1.

The analysis of inter-decadal growth rates in average yield showed a decline for all the clones during all the decades except for RRIM 600 during 1970s (Table 1). For the clone GT 1 the highest decline in average yield (-11.84%) was observed from 1960s to 1970s. The average of inter decadal growth rate in yield for the clone was negative (-5.88%). Though the growth rate in yield during 1970s was positive (5.71%) for RRIM 600, the average inter decadal growth rate in yield for the clone was negative (-2.92%). Compared to the other two clones, RRII 105 showed the highest inter-decadal decline (-9.66 %) in yield.

Table 1. **Inter decadal growth rate (%) in average yield**

Trees planted during	GT 1	RRIM 600	RRII 105
1960s	NA	NA	NA
1970s	-11.84	5.71	NA
1980s	-3.28	-11.56	-7.64
1990s	-2.53	NA	-11.67
Mean	-5.88	-2.92	-9.66

The analysis of time series data on planting density and tapping intensity for the three clones showed comparable trends (Table 2). The decadal changes in the planting densities were not significant. The average decadal growth rate of planting density for RRII 105 was negative (-3.76%) compared to positive growth rates in the cases of both RRIM 600 (4.39%) and GT 1 (0.25%). Conversely, there had been remarkable shift to low frequency tapping systems (LFTS) in the case of all the clones. The decline in tapping intensity varied from 89 per cent to 59 per cent in the case of GT 1 whereas it was 85 per cent to 67 per cent for RRIM 600 and 72 per cent to 53 per cent for RRII 105. The experimental results have indicated the cost-reducing and yield enhancing potential of LFTS (Vijayakumar *et al*., 2003). Hence, it is plausible to presume that with a stable planting density the shift to LFT is not expected to be yield depressing.

The decadal trends in yield clearly indicate the prevalence of yield fatigue among the selected clones in the traditional rubber growing regions in India. Although the decadal trends in yield fatigue has been reversed to certain extent by the higher yield

Table 2. **Decadal trends in average density of planting (trees ha^{-1}) growth rate (%) and tapping intensity (%)**

Decade	GT 1			RRIM 600			RRII 105		
	Density	Growth rate	Tapping intensity	Density	Growth rate	Tapping intensity	Density	Growth rate	Tapping intensity
1960	351	—	89	321	-	85	NA	NA	NA
1970	341	- 4.48	83	311	- 3.12	85	352	-	72
1980	356	4.40	74	348	11.90	67	342	- 2.84	69
1990	359	0.84	59	NA	NA	NA	326	- 4.68	53
Mean	353	0.25	76	327	4.39	79	340	- 3.76	65

NA: Not available

of HY clones like RRII 105, the trends in yield of the clone underline the inherent limitations. The observed changes in density of planting and shifts in tapping system are not expected to be yield depressing. Regional variations in decadal trends in yield performance of the clones were not evaluated due to non-availability of comparable data across the regions during the period under review. As the contributory factors for the observed yield fatigue over decades are construed to be the cumulative effect of depleting soil organic content and fertility as well as climate change the following points deserve attention for off shoot research programmes: (i) detailed multi-disciplinary investigations on the contributory factors for the observed trends in the estate sector; and (ii) initiating a continuous research programme for monitoring the clone and region-wise trends in yield over different planting cycles in selected estates and smallholdings from a long term policy perspective.

REFERENCES

ANRPC (2014). *Natural Rubber Trends and Statistics,* Association of Natural Rubber Producing Countries, **6**(3), p. 1.

Burger, K., Haridasan, V., Smit, H.P., Unni, R.G. and Zant (1995). *The Indian Rubber Economy: History, Analysis and Policy Perspectives,* Manohar Publishers, New Delhi, India, 233 p.

Chan, H.Y., Wong, C.B., Sivanadyan, K. and Pushparajah, E. (1974). Influence of soil morphology and physiology on leaf nutrient content and performance of *Hevea. Proceedings of Rubber Research Institute of Malaysia Planters' Conference,* 1974. Malaysia, pp. 115-126.

George, K. T. (1999). The natural rubber sector: emerging issues in 1990s. In: *Kerala's Economic Development: Issues and Problems*. (Ed. B.A. Prakash), Sage Publications, New Delhi, India, pp. 186-199.

George, K.T., Haridasan, V. and Sreekumar, B. (1988a). Role of government and structural changes in rubber plantation industry. *Economic and Political Weekly*, **23**(48): 158-166.

George, K.T., Joseph, T. and Joseph, T. (1988b). Evaluation of the yield performance of selected rubber planting materials in the context of the planting policy. *Indian Journal of Natural Rubber Research*, **1**(2):66-78.

IRSG (2014). *Rubber Statistical Bulletin,* International Rubber Study Group, Vol. 68, No. 7-9. p. 14.

Jacob, J. and George K.T. (2008). Ageing of mature area and declining yield profile of natural rubber in India. *Natural Rubber Research,* **21**(1&2): 109-118.

Karthikakuttyamma, M. (1995). *Effect of continuous cultivation of rubber (Hevea brasiliensis) on soil properties.* Ph.D Thesis, University of Kerala. 176 p.

Licy, J., Saraswathyamma, C.K. and Mercykutty, V.C. (1997). Promising rubber planting materials and the concept of multiclone planting. *Seminar on Reduction of Immaturity Period and New Clones of Hevea,* 1997, Kottayam, India.

RRII (2014). Unpublished data on commercial yield provided by the estate sector.

Sarma, P.V.S. (1947). *A Short Note on Rubber Plantation Industry in India*. Indian Rubber Board, Kottayam, India. 12 p.

Saraswathyamma, C.K. (2003). Advances in crop improvement in *Hevea* in the traditional rubber growing tract of India. In: *Global Competitiveness of Indian Rubber Plantation Industry, Rubber Planters' Conference, India 2002.*(Ed. C. Kuruvilla Jacob). Rubber Research Institute of India, Kottayam India, pp.101-116.

Ulaganathan, A., Gilkes, R.J., Nair, N.U., Jessy, M.D. and Swingman, N. (2010). Soil fertility changes due to repeated rubber cultivation. Abstracts. PLACROSYM XIX, Rubber Research Institute of India. Kerala. 135 p.

Vijayakumar, K.R., Thomas, K.U., Rajagopal, R. and Karunaichamy, K. (2003). Response of *Hevea* clones to low frequency tapping. *Proceedings of the International Workshop on Exploitation Technology*, 15-18 December 2003, Rubber Research Institute of India, Kottayam, India, pp. 17-42.