INCREMENTAL ECONOMIC WORTH OF THE FIRST HIGH YIELDING INDIAN HYBRID CLONE, RRII 105 OVER RRIM 600

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The successful release of RRII 105, the first high yielding Indian hybrid clone in 1980 was a game changer in the Indian rubber plantation sector. Until then the Malaysian clone RRIM 600 has been the ruling clone in India. RRII 105 could yield 369 $kgha^{-1}yr^{-1}$ more than RRIM 600. Large scale expansion of rubber cultivation in India during the 1980s using RRII 105 made India a significant rubber producing country, productivity ranking the highest in the world and meeting almost the entire demand for rubber from domestic production for several years. The production-consumption gap started to widen with the current price decline from the beginning of this decade.

The present analyses show that during the period between 1991 and 2017, the total economic value of the incremental yield produced by RRII 105 (over RRIM 600) in India was to the tune of USD 6635 million. This translated into maximum incremental revenue of Rs. 28,000 per grower per year in 2011-12 when the number of growers was as high as 1.2 million. Bringing such a substantial economic benefit to a large number of farmers as a result of just one innovation, namely RRII 105 has no parallel in Indian agriculture.

To avoid the risk of extensive monoclonal planting more number of high yielding, climate-resilient "smart clones" with fast growth rate, high timber yield and pest/disease tolerance should be released in quick succession. The present rubber breeding cycle of 25 years is too long. Towards achieving the objective of shorter breeding cycle, advanced breeding tools such as molecular breeding, marker assisted selection and genetic engineering should be adopted.

Key words: Economic worth, High yielding clones, Incremental yield, RRII 105, RRIM 600

INTRODUCTION

Experimental planting of natural rubber (NR) in India was initiated as early as 1873 at the Botanical Gardens, Calcutta, but was a failure due to climatic reasons (Prain, 1914; Dean, 1987). Later in 1878 it was introduced as a forest crop in South India with rooted cuttings imported from Royal Botanic Gardens, Heneratgoda, Ceylon (Royal Botanic Gardens, 1898) where the original Wickham collection was conserved. But it was the large scale introduction of NR seeds during the early years of the 20th century and subsequently hybrid clones from countries like Ceylon, Malaya, Java *etc*. that established viable commercial NR plantations in India (Jacob *et al*., 2013). Long before selections and hybrid clones were developed through breeding and selection research, high quality

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seeds were the predominant planting material of this crop. Natural rubber seeds were considered so precious for establishing plantations that there was a time when their export out of Malaya was legally banned (Rubber Board, 1957).

Corporate company estates such as the Harrisons and Crossfield dominated the early global NR plantation sector and they were the sole monopoly to import rubber seeds to India from their counterpart estates in other countries (George, 2011). Malaya was the leading NR producing country during early 20th century and the Rubber Research Institute of Malaysia (RRIM) founded in 1925 released the clone RRIM 600 during 1937-1941 (Malaysian Rubber Board, 2017). This clone became very popular not only in Malaya, but in almost every NR growing country in the world, including India, where this was the ruling clone until the early 1980s.

The Rubber Research Institute of India (RRII), established in 1955 released its first high yielding hybrid clone, RRII 105 in 1980 (Saraswathyamma *et al*., 2000) and this became extremely popular with the Indian growers almost instantly, replacing RRIM 600 as the preferred clone. Apart from the yield advantage of RRII 105 over RRIM 600, the former also had much better tolerance to abnormal leaf fall disease which is widespread in the traditional rubber growing regions of India (George *et al*., 1980). RRIM 600 is highly susceptible to this fungal disease (Mushriff *et al*., 2004) which is the main reason for its lower yield in regions of India where this disease is common.

The decade of the 1980s witnessed the fastest growth in NR cultivation in India and RRII 105 was widely planted since then. Until the next generation hybrids in the RRII 400 series clones were released in 2005 and 2009, by and large RRII 105 was the only major clone that was planted in the country. As of 2017, the total area under NR in the country was 8,18,000 ha out of which tappable area was about 5,86,000 ha and RRII 105 occupied close to 90 per cent of the tappable area.

The high yield potential of RRII 105 and its total adoption by the Indian growers (Ipe and Haridasan, 1988; Veeraputhran *et al*., 1998; Chandy and Sreelakshmi, 2008) catapulted India to the top position in the world in terms of NR productivity in 2006-07 (Rubber Board, 2007). The phenomenal developments witnessed since the 1980s in terms of expansion of area and the subsequent increase in productivity and rise in production by the Indian NR plantation sector have been as spectacular as the developments in the green revolution crops (George and Kurian, 1997). The country could achieve near self-sufficiency in NR production until 2006-07 (Rubber Board, 2009). This has been possible largely due to the high yielding potential of RRII 105 and the total adoption of this clone by the Indian growers.

However, no attempt has been made to quantify the monetary benefits accrued due to the cultivation of RRII 105 in the country over the years. In the present study we have worked out the value of output of the incremental yield of RRII 105 over RRIM 600 over a period of 26 years between 1991 and 2017.

MATERIALS AND METHODS

Released in 1980, cultivation of RRII 105 quickly expanded to large areas during the 1980s and the following decades. Due to the long gestation period of about seven years and relatively low yields in the early years of tapping this clone began to make gradual contribution to the total rubber production in the country only from the early 1990s onwards and this steadily increased over the years since then. Using the data on adoption

of high yielding clones (various issues of Indian Rubber Statistics) and earlier studies on adoption of RRII 105 (Ipe and Haridasan, 1988; Veeraputhran *et al*., 1998), the extent of tapped area that fell under RRII 105 every year from 1991 to 2017 was estimated which increased gradually from 10 per cent in 1987-88 to 90 per cent of the total tappable area in 1995-96 and it remained at this level thereafter. The average incremental life cycle yield of 369 kg ha^{-1} yr^{-1} of RRII 105 over RRIM 600 (*i.e.* difference in the yields between the two clones per ha per year based on life cycle yield), estimated from the data obtained from the estate sector in the traditional belt covering 9669 ha (Chandy and Sreelakshmi, 2008), was used to estimate the total incremental yield of RRII 105 over RRIM 600 every year from 1991 until 2017. It is assumed in the present analysis that had RRII 105 or an equally good Indian clone not been released, cultivation of RRIM 600 would have continued and this would have resulted in far less production (approx. 1.4 lakh tonnes $year^{-1}$) of NR than what India has actually produced through extensive cultivation of RRII 105 (Fig. 1). To convert the incremental yield from RRII 105 (over that from RRIM 600) in each year since 1991 to monetary value, the price of RSS 4 (the predominant grade of rubber produced in India) in the domestic market every year was used and the value so obtained was converted to US dollars using the exchange rates in the corresponding year (Reserve Bank of India, 2017). Thus we estimated the total incremental yield produced by RRII 105 from the entire tapped area and its incremental economic worth for every year from 1991 to 2017.

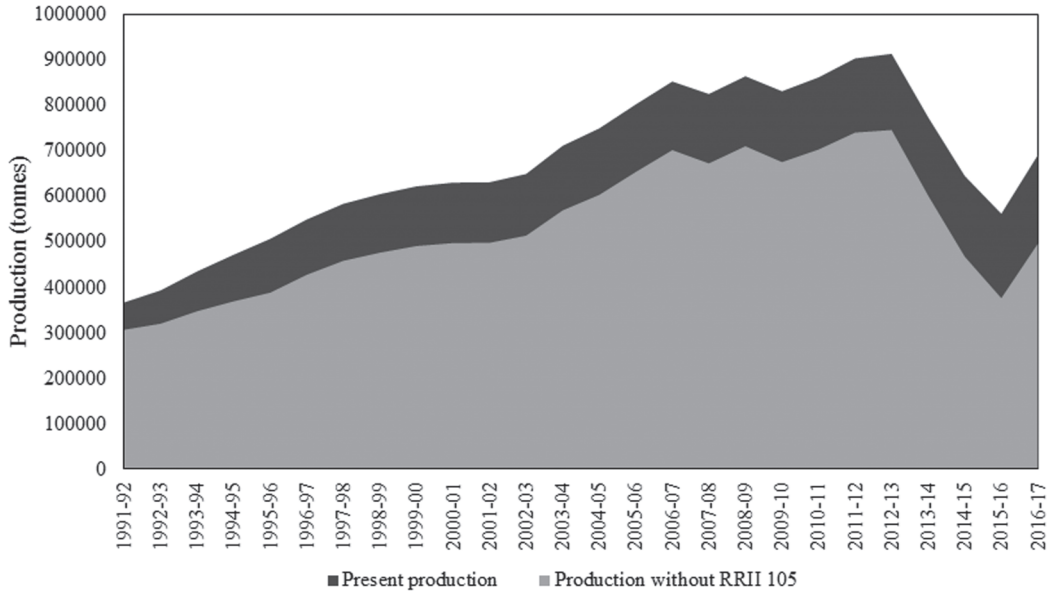

Fig. 1. Production of natural rubber in India (1991 to 2017)

RESULTS AND DISCUSSION

Technological advancement leads to an upward shift in the production function as a result of improved resource use efficiency and increased productivity (Doll and Orazem, 1984). In the case of NR production in India, breeding research initiated at RRII during 1954 (Nair and Panikkar, 1966) culminated in the successful release of the first high yielding Indian hybrid clone, RRII

Table 1. **Estimated value of the incremental production from RRII 105 over RRIM 600 between 1991 and 2017**

Year	Total tappable area (ha)	Area under RRII 105 (ha)	Total Incremental production from RRII 105 (kg)	Mean price of RSS 4 ($RsKg^{-1}$)	Cash value of incremental production from RRII 105 (Crore Rs)	US Dollar to Rupees exchange rate (US $)	Cash value of incremental production from RRII 105 (million US $)
1991-92	324540	162270	59877630	21.41	128.2	24.47	52.4
1992-93	330500	198300	73172700	25.50	186.7	30.65	60.9
1993-94	338550	236985	87447465	25.69	225.7	31.37	71.6
1994-95	346270	277016	102218904	36.38	371.9	31.40	118.4
1995-96	356444	320799	118375052	52.04	616.0	33.45	184.2
1996-97	365580	329022	121409118	49.01	595.0	35.50	167.6
1997-98	376970	339273	125191737	35.80	448.2	37.16	120.6
1998-99	387100	348390	128555910	29.94	384.9	42.07	91.5
1999-00	394800	355320	131113080	30.99	406.3	43.33	93.8
2000-01	399901	359910	132807122	30.36	403.2	45.68	88.3
2001-02	400713	360641	133076787	32.28	429.6	47.69	90.1
2002-03	407953	367157	135481191	39.19	531.0	48.40	109.7
2003-04	427935	385141	142117213	50.40	716.3	45.95	155.9
2004-05	439720	395748	146031012	55.71	813.5	44.93	181.1
2005-06	447015	402313	148453681	66.99	994.5	44.27	224.6
2006-07	454020	408618	150780042	92.04	1387.8	45.28	306.5
2007-08	458830	412947	152377443	90.85	1384.4	40.24	344.0
2008-09	463130	416817	153805473	101.12	1555.3	45.92	338.7
2009-10	468480	421632	155582208	114.98	1788.9	47.42	377.2
2010-11	477230	429507	158488083	190.03	3011.8	45.58	660.8
2011-12	490970	441873	163051137	208.05	3392.3	47.92	707.9
2012-13	504040	453636	167391684	168.80	2825.6	54.41	519.3
2013-14	518100	466290	172061010	166.02	2856.6	60.50	472.2
2014-15	533675	480307	177233467	132.57	2349.6	61.14	384.3
2015-16	558900	503010	185610690	113.06	2098.5	65.46	320.6
2016-17	586000	527400	194610600	135.50	2637.0	67.10	393.0
						Total	**6635.2**

105 in 1980 (Saraswathyamma *et al*., 2000). This high yielding clone was a definite technological advancement and a historic milestone as the clone replaced all other clones in India in a short period of time and made India a significant NR producing country. Total annual production increased from under 1,50,000 tonnes year^{-1} in the 1970s to about 8, 00,000 tonnes year^{-1} by 2010-11. During this period, mean productivity increased from about 750 kg ha^{-1}year^{-1} to close to 1800 kg ha^{-1} year^{-1} (Rubber Board 2003; 2013); thanks to the high yield of RRII 105 and its total adoption by growers. The exclusive preference of the growers for RRII 105 led to extensive mono-clonal planting in India (Ipe and Haridasan, 1988; Veeraputhran *et al*., 1998, 2012; Chandy *et al*., 2004) which is the flip side of this technological advancement. The wide popularity of RRII 105 was fueled by the quantum jump in the yield potential of this clone as compared to the previously popular clone, RRIM 600 (Chandy and Sreelakshmi, 2008).

The decade of the 1980s witnessed the fastest rate of growth in area under NR cultivation in India (Rubber Board, 2003). The release of RRII 105 in 1980 (which had become quite popular even earlier to 1980), the emergence of the small growers in large numbers, the then prevailing socio-economic factors that prompted large scale conversion of other crops such as coconut, cashew *etc*. into NR holdings, highly visible and proactive promotional activities by the Rubber Board, especially an attractive planting subsidy which could meet almost 25 per cent of the development cost in the 1980s (Chandy *et al*., 2015) were some of the reasons behind the NR boom witnessed in India during the 1980s.

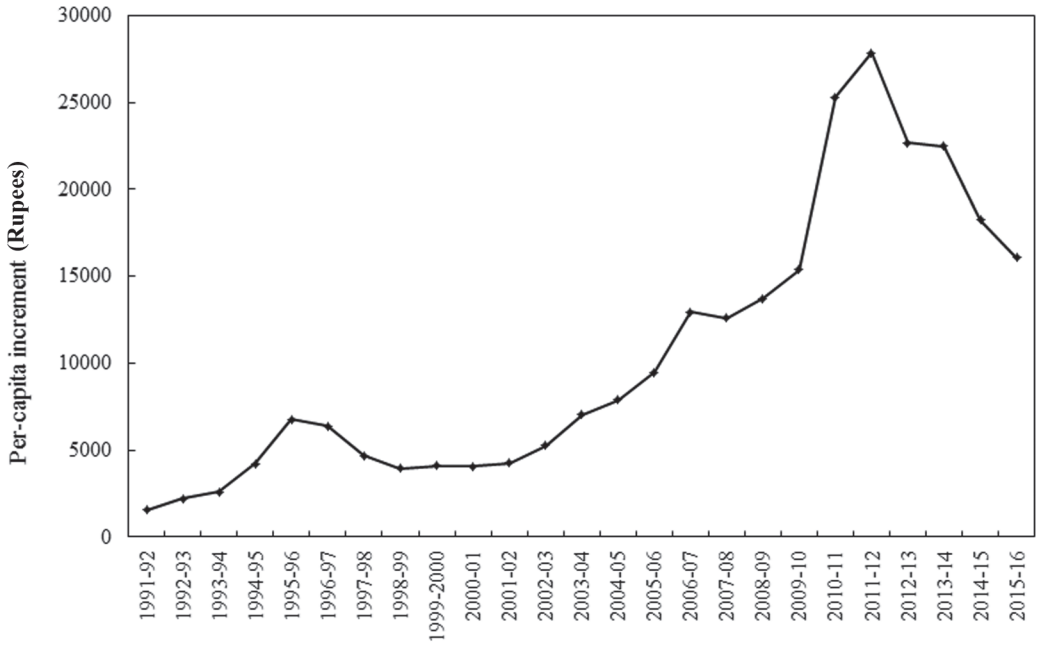

Fig. 2. Annual per capita incremental farm income due to cultivation of RRII 105. (Decline after 2010-11 has been largely due to drop in rubber price)

The present analysis shows that during the period between 1991 and 2017, the total economic value of the incremental yield produced by RRII 105 (over RRIM 600) in India has been a whooping USD 6635 million (Table 1). Two reasons are behind this remarkable performance, namely the markedly high yield of RRII 105 over RRIM 600 and the significant expansion in NR cultivation using this clone. While the breeding team at RRII in its early years can rightfully take full credit for developing RRII 105, the extension officers of the Rubber Board should also get their due credit for taking this new clone to a grower community and making them whole heartedly accept it at a time when Malaysia was the world leader in NR production and its flagship clone RRIM 600 was the ruling clone among the Indian growers.

The cash value of the incremental yield from RRII 105 (over and above that from RRIM 600) the Indian rubber grower got due to cultivating this clone rose from a couple of thousands of rupees in the 1990s to close to Rs. 28,000 per grower per year in 2011-12 (Fig. 2) at a time when the total number of beneficiary growers was as high as 1.2 million. (Since then, the revenue declined largely due to declining price of rubber). Bringing such a substantial economic benefit to a huge number of farmers as a result of just one innovation, namely RRII 105 perhaps has no parallel in Indian agriculture.

A close look at the history of agricultural research in India (as well as other countries) will show that the single R and D outcome from any agricultural research institute that had the most profound impact on the farming community was always the high yielding crop varieties these institutes could release (Alexandratos, 1995). High yielding varieties of cereal crops developed through genetic improvement research were the main contributions of the various national and international research institutes which ushered in the era of green revolution in India and many other developing countries (FAO, 2003; Pingali and Raney, 2005). Improved irrigation techniques, fertilisers and pesticides *etc*. would have made little impact on food production but for the emergence of high yielding crop varieties that had the genetic potential to favourably respond to these inputs (Newman, 2007).

In the case of NR too, it was the development of high yielding hybrid clones through genetic improvement research that was primarily responsible for increasing production in every NR growing country (Jacob *et al*., 2013). RRII 105 has made seminal contributions to the Indian NR plantation industry and the economic benefits reaped by a large number of growers of this clone have perhaps no parallel in other NR growing countries. Had there been no RRII 105 (or another similar high yielder released by RRII in the 1980s), Indian growers would have continued to cultivate RRIM 600 and the loss in NR production in the country would have been huge. This would have resulted in the Indian growers making far less profits and the country losing huge foreign exchange as a result of import of NR to meet the domestic industrial demand which increased several fold in the past couple of decades.

The newly released RRII 400 series clones (2005 and 2009) are now increasingly getting planted in India, gradually replacing RRII 105 from the field. It is estimated that during 2004 to 2010 on an average 28 per cent of the area planted each year is planted with RRII 400 series clones (Veeraputhran *et al*., 2013) and this is steadily on the rise. However, with the rather slow pace of replanting in India, it will take several years before most of the current area under RRII

105 is replaced with the RRII 400 series clones and the benefits of the new clones are realised by the growers.

CONCLUSION

One single contribution of RRII, namely release of its first high yielding hybrid clone, RRII 105 gave a huge impetus to the NR plantation industry in the country and the perceived prosperity of the Indian rubber grower can be largely attributed to this single clone which has been a game changer. More contributions have been made in other areas of R and D at RRII such as sustainable rubber production, crop protection, crop management, soil conservation, environmental protection *etc*. impact of which are less easy to quantify in monetary terms. Intense research needs to be done to sustain NR cultivation in the country in the years ahead which are characterised by social, economic and climatic uncertainties, declining soil health, newly emerging pests and diseases, environmental concerns *etc.*

High yielding clones will continue to be the mainstay and future "smart clones" should be climate-resilient smart clones capable of surviving adverse environmental stresses with fast growth rate, high rubber and timber yields and pest/disease tolerance. To avoid the risk of extensive monoclonal planting in future and given the fast changes that are occurring to climate, release of climate-resilient "smart clones" should happen at short intervals. The present classical approach of breeding and selection to develop a new clone takes nearly a quarter of a century to come to fruition, and that too only if the breeder is lucky. To develop and release new clones at quicker succession, we need to adopt advanced breeding tools such as molecular breeding, marked assisted selection and genetic engineering.

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