Rubber Science, **30**(1): 66-75, 2017 *RESEARCH ARTICLE*

TRENDS IN SEASONALITY OF NATURAL RUBBER PRODUCTION IN MAJOR PRODUCING COUNTRIES: A DISAGGREGATE LEVEL ANALYSIS

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Received: 27 January 2017 Accepted: 13 March 2017

Veeraputhran, S., Raj, S. and George, K.T. (2017). Trends in seasonality of natural rubber production in major producing countries: A disaggregate level analysis. *Rubber Science*, **30**(1): 66-75.

This paper examines the seasonality in the production of natural rubber (NR) and whether it has changed in the major producing countries like Thailand, Indonesia, Malaysia and India in the context of fall in the production and productivity of NR. Using the monthly data on production of NR and the technique of change-point analysis, the trends in seasonality at aggregate level (over period) and disaggregate level (within months) was examined for the 23 years period from 1991 to 2013. At aggregate level,seasonality in NR production remained the same in these countries over the period. At disaggregate level also the pattern remained the same in Thailand and Malaysia when it displayed significant changes in India and Indonesia since 1998. Changes in production at disaggregate level are indicative of impending changes in the seasonality of NR production in India and Indonesia. Hence, it is imperative to initiate a multidisciplinary investigation to explore the underlying factors for ensuring the sustainability of commercial cultivation of NR in these countries.

Key words: Change-point analysis, Climate change, Natural rubber, Production, Seasonality

INTRODUCTION

To a large extent, farm management decisions, prices of agricultural commodities and public policy on market interventions are dependent on seasonality in the production of crops (Lele, 1971; Tomek and Robinson, 1981; Goetz and Weber, 1986; Gilbert, 2006). However, compared to annual crops, seasonality in production assumes critical importance for perennial crops like natural rubber (NR) due to its long gestation period and a life cycle of more than 25 years. In the recent past, the pivotal role of weather and climate change effects on production and productivity of agricultural commodities across the countries has attracted wider attention (Rosenzweig and Parry,1994; Olesen and Bindi, 2002; Parry *et al.*, 2004; IPCC, 2007; Mark *et al*, 2008; Teixeira *et al.*, 2013). Rosegrant *et al.* (2010) highlighted some of the direct impacts of climate change on agricultural system as: (a) seasonal changes in rainfall and temperature which could impact the agro-climatic conditions, altering growing seasons, planting and harvesting calendars, water availability, pest, weed and disease populations; (b) alteration in evapotranspiration, photosynthesis and biomass production; and (c) alteration in land suitability for agricultural production.

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In the case of NR, Manton *et al.* (2001) argued that, climate change is one of the important factors that may seriously jeopardize the availability of NR in India and other major producing countries in South and Southeast Asia, a region particularly vulnerable to adverse impacts of climate change. It is reported that a unit degree rise in maximum and minimum temperature may reduce the productivity further at least by 5 to15 per cent in India depending upon the agro-climatic regions (Satheesh and Jacob, 2011). In India, changing weather and climatic factors had adversely affected the domestic NR production and productivity during recent years and in the next ten years it can go down by 5.6 per cent in the traditional region and by 3.7 per cent in the dry and hot non-traditional regions owing to warming conditions (Jacob *et al.*, 2012 and 2015). In Malaysia, production is expected to decrease by 10 to 30 per cent in the next few decades owing to extreme climate change (Siwar *et al.*, 2013). Similarly, it is reported that a 10 °C rise in temperature in Indonesia would inhibit the productivity of NR by 20 per cent (Yogaratnam, 2011). Thailand is also skeptical about achieving the targeted NR production and productivity since the maximum temperature had increased considerably during the last 30 year period from 1980 to 2010 (Chantuma, 2012; Sdoodee and Rongsawat, 2012). Because, climate conditions such as dry period and low temperature delayed rubber growth in Thailand (Sangsing, 2010). It could be one of the factors attributed to the fall in the rate of growth in NR production and productivity during the last one decade in major producing countries like Thailand, Indonesia, Malaysia and India supports these observations. In this background, an investigation into the seasonality in the production of NR in these countries is required to find out whethere any change in the production of NR could be detected since it accounts for 70 per cent of the global NR production, would have changed owing to climate and weather changes. An analysis of seasonality of NR assumes vital importance for evolving agro-management policies and strategies for the sustainability of NR cultivation for its commercial importance as strategic raw material and as livelihood source for a sizeable population of growers and labourers in these countries. However, exploring the climatic factors affecting the production of NR in these countries is beyond the scope of this study. Therefore this study was undertaken with the following specific objectives;

(a) to identify the seasonality in NR production in the major NR producing countries *viz.* Thailand, Indonesia, Malaysia and India;

(b) to examine any discernible change, if any, in the seasonality at the aggregate level (over period) in these countries;

(c) to analyse the occurrences of any change in seasonality at the disaggregate (intra-month) level across these countries; and

(d) to suggest policy implications of the findings.

MATERIALS AND METHODS

The study was based on monthly production data of NR in Thailand, Indonesia, Malaysia and India for the 23 years period from 1991 to 2013. The choice of period was guided by the availability of comparable data in major producing countries. The analysis was purposefully limited up to 2013 to avoid the possible influence of consistent decline in NR production arcross these countries since 2011 (www.rubberboard.org.in). The required data were collected from different issues of the Indian Rubber Statistics published by the Rubber Board, India, and the Monthly Statistical Bulletin and Natural Rubber Trends and Statistics published by the Association of Natural Rubber Producing Countries (ANRPC), Kuala Lumpur, Malaysia during 1992 and 2015. The analysis of seasonality was based on percentage share of monthly production in annual production during the 23 years period. Mean variability in the monthly production over the period was studied based on the coefficient of variation (CV). The data on monthly production shares for the four countries were subjected to analysis of variance (ANOVA) and calculation of the Fisher's Least Significant Differences (LSD) for grouping it into peak, moderate and lean periods, respectively. The analysis was conducted after square root transformation of the percentage data. In order to capture the occurrences of statistically abrupt changes and trends in seasonality within each country, Change-Point Analysis (CPA) (Taylor, 2000a and 2000b; Killick *et al.*, 2010) was utilised in the time series data set. The CPA performs this analysis using the method of cumulative sum charts (CUSUM) and bootstrapping (Davison and Hinkley, 1997). The CUSUM and bootstrapping are used for the detection of abrupt changes/breaks/jumps on a time series. Section of the CUSUM chart with an ascending trend indicates a period when the values remain above the overall average. Likewise, a section with a descending trend indicates

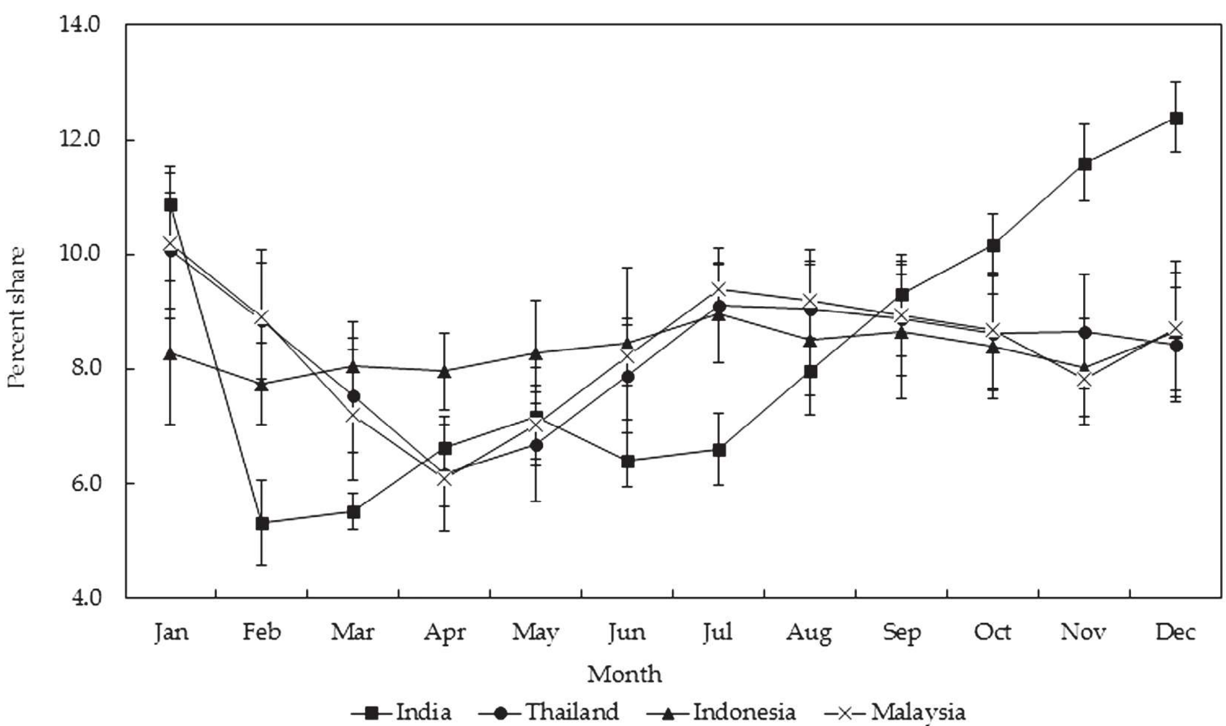


Fig. 1. Monthly production of NR in India, Thailand, Indonesia and Malaysia during 1991-2013 (% share in total production)

a period of time where the values lie below the overall average. The monthly production shares were subjected to the CPA for identification of structural breaks in both the aggregate and disaggregate levels of analysis to identify the seasonal changes and their nature before and after such breaks.

RESULTS AND DISCUSSION

Seasonality at aggregate level

The trends in monthly average production shares of NR in the four major rubber producing countries (Thailand, Indonesia, Malaysia and India) during the period from 1991 to 2013 are illustrated in Fig. 1.

It can be seen from Fig.1 that trends in production are almost identical in Thailand, Indonesia and Malaysia, especially in the second half of the year. Generally, production is seen higher during July to January and low during February to June. In the case of Thailand and Malaysia, the maximum production takes place during the month of January (10.0% and 10.2%, respectively) and the minimum production during April (6.2% and 6.0%, respectively) (Table 1). It can also be observed that from February to April NR production consistently declined but showed a moderate increase for the next three months from May to July and afterwards it remained at a higher level up to January. Indonesia is unique as its monthly production is relatively stable fluctuating between 9.0 and 7.7 per cent. Unlike other countries, monthly production in India is peculiar in the sense that it is relatively low in the first half of the year but consistently increases from the month of July to December with maximum and minimum production during the months of December (12.4%) and February (5.4%).

Thailand, Malaysia and Indonesia have near identical pattern in monthly

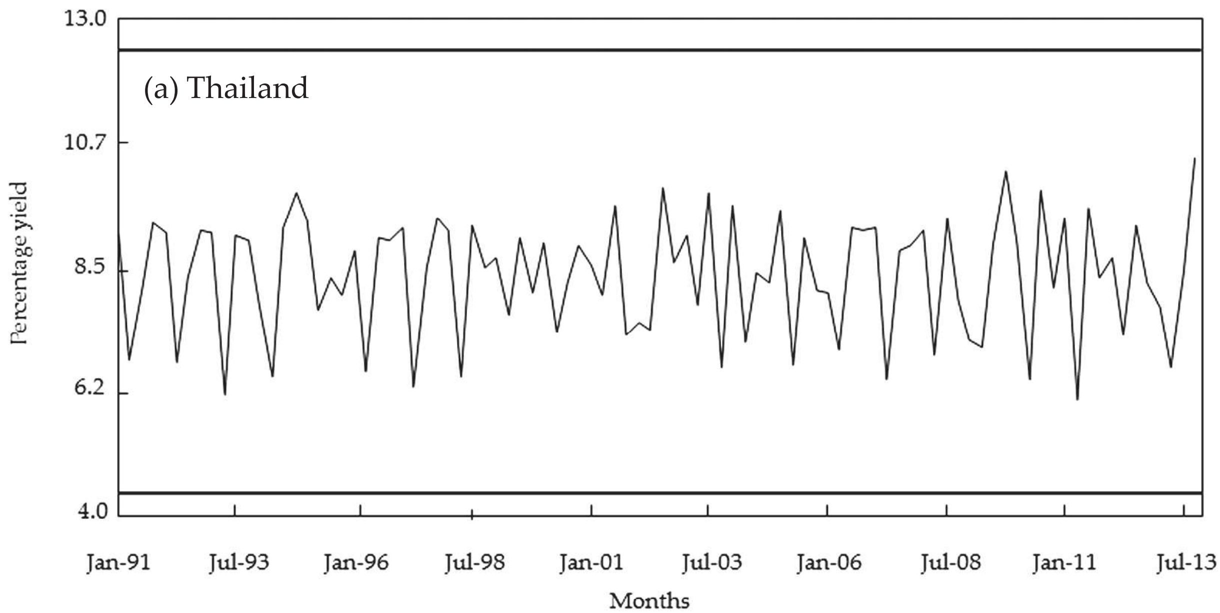
Table 1. **Mean monthly production with the co-efficient of variation (CV) for the four NR producing countries and its statistically grouped peak, moderate and lean seasons.**

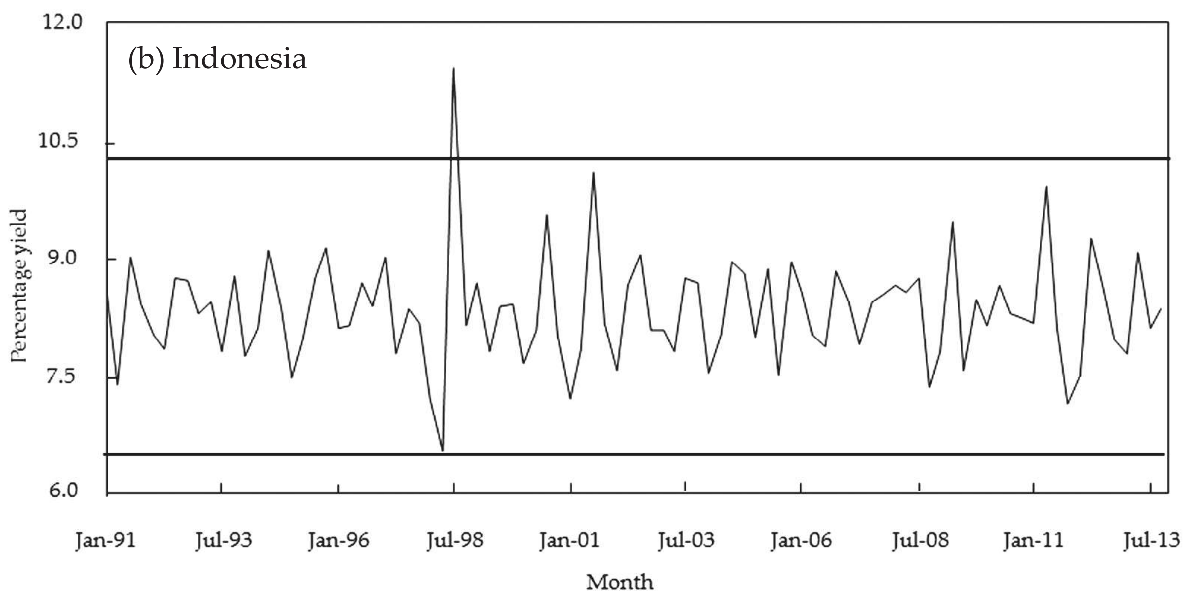
Months	Production (% of total production) with variability							
	Indonesia	CV	Thailand	CV	Malaysia	CV	India	CV
Jan	8.3_{bcd}	14.5	10.0_{a}	11.4	10.2_{a}	12.1	10.9_{c}	5.4
Feb	7.7_{d}	8.8	8.7_{b}	11.8	8.9_{bcd}	12.9	5.4_{i}	15.4
Mar	8.1_{bcd}	9.4	7.6_{d}	17.6	7.2_{g}	15.9	5.6_{i}	6.3
Apr	8.0_{cd}	7.9	6.2_{e}	15.3	6.0_{h}	9.2	6.6_{h}	6.1
May	8.3_{bc}	10.5	6.6_{e}	11.8	7.0_{g}	8.7	7.2_{g}	11.8
Jun	8.5_{abc}	15.3	7.9_{cd}	15.8	8.2_{ef}	6.2	6.3_{h}	9.6
Jul	9.0_{a}	9.3	9.1_{b}	10.9	9.4_{b}	4.6	6.6_{h}	9.9
Aug	8.5_{abc}	15.0	9.1_{b}	9.5	9.1_{bc}	6.6	8.0_{f}	5.5
Sep	8.6_{ab}	13.4	8.8_{b}	12.0	8.9_{bcd}	7.3	9.2_{e}	7.4
Oct	8.4_{bc}	10.3	8.7_{b}	12.1	8.6_{de}	11.7	10.2_{d}	5.1
Nov	8.1_{bcd}	10.4	8.8_{b}	15.6	7.8_{f}	9.8	11.6_{b}	5.8
Dec	8.5_{ab}	11.4	8.5_{b}	20.2	8.7_{cde}	13.1	12.4_{a}	4.8

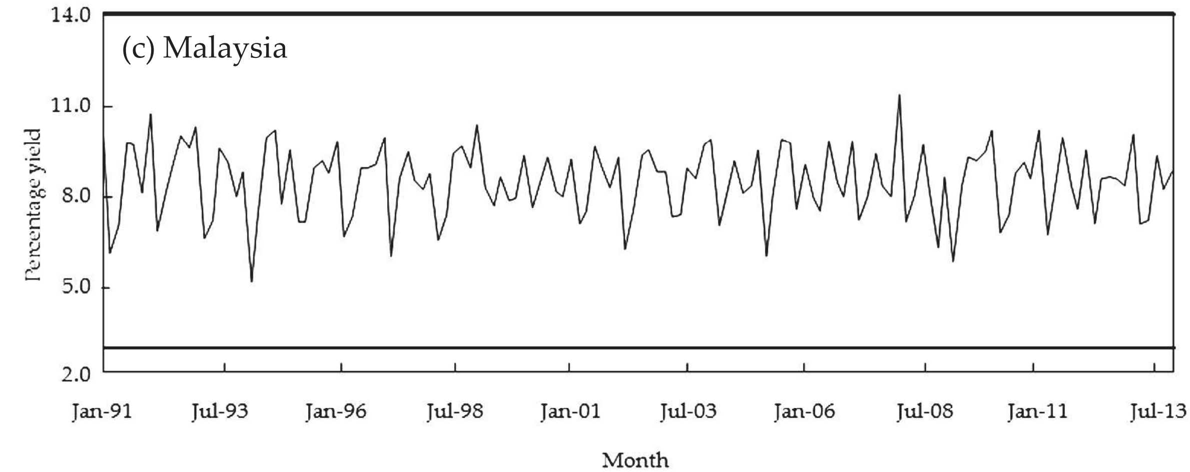
Peak Moderate Lean Seasons

Note: Subscripts indicate Fisher's Least Significant Differences (LSD) production compared to that of India. The major rubber growing areas in Thailand, Malaysia and Indonesia are blessed with an equatorial type of climate compared to the monsoon climate experienced in India's important rubber growing regions. Based on monthly average production shares over the study period, it is observed that when India has three seasons (peak, moderate and lean) Thailand and Malaysia have only two seasons (peak and moderate) and Indonesia has no season at all *ie* production in Indonesia is almost stable throughout the year (Table 1).

It can be seen from Table 1 that the peak season in Thailand extends for nine months from June to February (80%) and the moderate season for three months from March to May (20%). Production in Malaysia also shows that its peak season begins from June to February (80 per cent) and that of







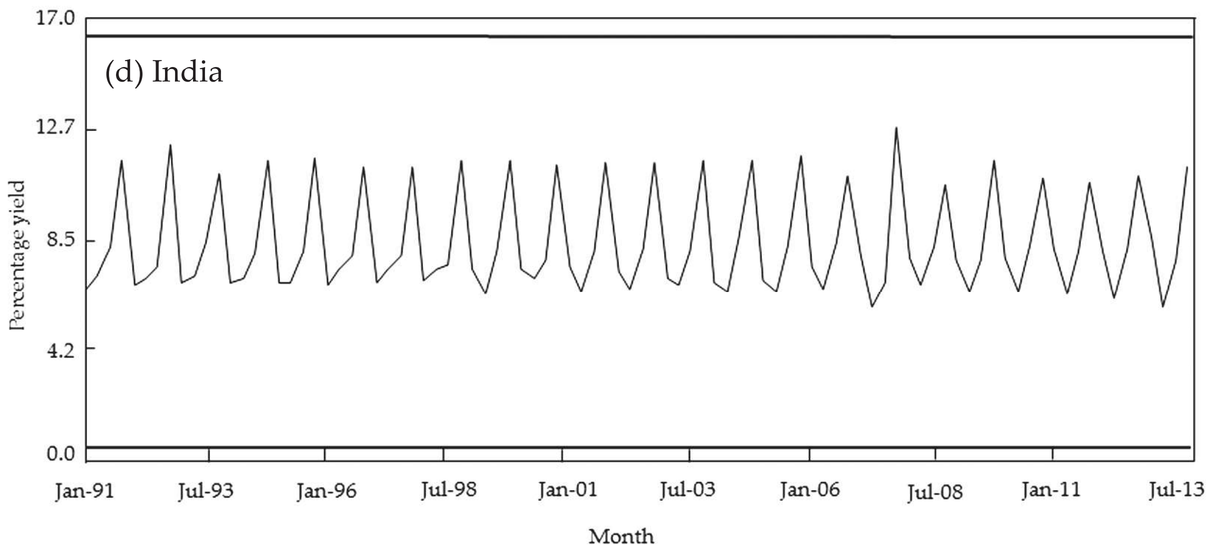


Fig. 2(a-d). Result of the CPA analysis showing no breaks in NR production at the aggregate level for the four countries during 1991-2013

the moderate season from March to May (20%). In contrast to this, in India the peak season represents only six months from August to January (62%) with February to March as lean (11%) and April to July as moderate (27%) seasons. Thus, the mean monthly shares in production clearly show that seasonality in the production of NR is higher in India followed by Thailand and Malaysia and no seasonality in Indonesia. Thus is also evident from the differences between the average shares of production during the peak and moderate or lean periods in these countries. In India, the difference is 4.9 per cent whereas, in Thailand and Malaysia it is 2.0 and 2.1 per cent, respectively. Variability (CV) in monthly production (Table 1) is found to be more volatile in India followed by Thailand, Malaysia and Indonesia. However, it needs to be underlined that variability in production is directly related to yielding periods variability in production is higher during the peak period and is lower in the

Table 2. **Significant changes in yield for different months with the respective confidence intervals, differences and levels for India (1991-2013)**

Month	Year	Confidence interval	Confidence level	Monthly share in production		Level
				From	To	
February	2007	2007,2007	97%	5.0	6.4	3
March	1999	1992,2008	98%	5.3	5.5	3
	2009	2007,2009	100%	5.5	6.1	1
April	2001	2001,2001	100%	7.0	6.3	1
May	1999	1998,2000	100%	8.2	6.6	1
June	2013	2011,2013	98%	6.4	4.5	2
September	1998	1993,2000	97%	10.0	8.9	1
November	2008	2005,2009	98%	11.8	10.8	3

lean/moderate season in India, Thailand, and Malaysia. Against this backdrop it was attempted to examine as to whether the trends in the monthly production had witnessed structural breaks over the period in these countries so as to identify the seasonal changes and their nature before and after such breaks. The CPA was used to identify the structural breaks during the 23 years period.

Change-point analysis was initially performed on the serially arranged dataset for each country to identify abrupt breaks in the monthly production at the aggregate level. However, a significant break could not be established at the aggregate level (Fig. 2a-d). Therefore, it was attempted to detect whether production had witnessed any trend/structural breaks at disaggregate level (month-wise or intra-month) over the period. The CPA analysis at disaggregate levels revealed structural breaks only in Indonesia and India and no significant breaks in the case of Malaysia and Thailand. Therefore, for brevity sake the structural breaks only for Indonesia and India are discussed.

Seasonality at disaggregate level

In India significant breaks in the month-wise production were witnessed for seven months *viz.* February, March, April, May, June, September and November within the study period (Table 2).

It can be seen from Table 2 that structural break for the month of February was witnessed in 2007. Until 2006, the average share of production in February in total production was 5.0 per cent but since 2007 onwards it had been 6.4 per cent. That is, an increase of 1.4 percentage points was observed after 2007. The month of March showed two breaks in 1999 and 2009. Up to 1998 the average share was 5.3 per cent, but from 1999 to 2008 the share increased from 5.3 to 5.5 per cent and again from 2009 onwards it increased from 5.5 to 6.1 per cent *ie.* the increase in production was 0.2 and 0.6 percentage points, respectively after the two breaks. In the case of May, production increased by 0.7 percentage points after the break in 2009. However, in the months of April, May, June, September and November breaks were detected in 2001, 1999, 2013, 1998 and 2008, respectively. It can be

Table 3. **Significant changes for different months with the respective confidence intervals differences and levels for Indonesia (1991-2013)**

Month	Year	Confidence interval	Confidence level	Monthly share in production		Level
				From	To	
May	2006	(2001,2007)	97%	7.9	9.1	2
July	1998	(1992,1998)	100%	8.6	9.8	1
	2004	(2004,2004)	97%	9.8	8.8	2
August	2002	(1999,2005)	97%	9.2	7.8	2

observed that production levels were following a decreasing trend during these months after the break. In effect, results showed that there was a consistent increasing trend in production during the lean period and a decreasing trend during the moderate and the early peak seasons in India.

In Indonesia, it can be seen that significant trend breaks were witnessed in the production for three months *viz.* May, July and August during the 23 year period (Table 3).

It can be seen from Table 3 that structural breaks for the month of May took place in 2006. Until 2005, the average share of May in total production had been 7.9 per cent and after which it had been at the level of 9.1 per cent until 2013, production during the month of May had been 1.2 percentage points higher since 2006. The month of July witnessed two breaks (Table 3) in 1998 and 2004 over the period. From 1991 to 1997 the average share of production of July had been 8.6 per cent, and from 1998 to 2003 it had been at a higher level of 9.8 per cent, but since 2004 till 2013 it had declined to the level of 8.8 per cent. In the case of August significant break occurred in 2002. Table 3 reveals that until 2001, the average share of production had been 9.2 per cent, but afterwards it declined to the level of 7.8 per cent until 2013. Precisely production trend showed an increasing trend in the month of May, but it showed a decreasing trend in July and August after the break. However, in the case of Malaysia and Thailand, no significant structural break could be observed in NR production at disaggregate level showing that there had been little or no change in the seasonality for the two adjacent countries. Thus, the analysis shows that seasonality in production at aggregate level had not changed across the countries over the years. However, at disaggregate level, change had occurred in the case of India and Indonesia. It can be observed that the comparative stability in the seasonality in production at aggregate and disaggregate levels in Thailand and Malaysia could be due to factors other than changes in agro-climate, including the expansion of area under NR to less favourable non-traditional regions (Damarjati and Jacob, 2010) and increasing share of senile trees in the tapped area (Jacob and George, 2016). In due course, influence of these factors may lead to changes in the composition of prevailing seasonality in these countries. Hence, it can be perceived that changes at disaggregate levels indicate the impending changes in the seasonality at aggregate level.

CONCLUSION

The study attempted to analyse the trends in seasonal pattern of NR production in the four major producing countries *viz.* Thailand, Indonesia, Malaysia and India at the aggregate and disaggregate levelsduring the past two decades from 1991 to 2013. The analysis at aggregate level showed that when the major NR producing countries experience either two seasons (peak and moderate as in Thailand and Malaysia) or no season (Indonesia) of production, India has three seasons of (peak, normal and lean) of production. While no marked seasons could be detected in Indonesia, the month from June to February represent the peak seasons and the month from March to May represent the moderate seasons in Malaysia and Thailand. In the case of India, the months from August to January, April to July, and February to March represent the peak, moderate and lean seasons, respectively. In general, seasonality is more prominent in India compared to other countries.

However, at the disaggregate level, monthly production had been found to be varying significantly in Indonesia and India since 1998. The extent and magnitude of variability were higher in India compared to Indonesia. In Malaysia and Thailand such significant variations could not be observed even at disaggregate levels. An interesting fact observed in the case of India is the increasing trend of production during the lean season and the subsequent decreasing trend during the moderate and early peak season is suggestive of a shift in the nature of production (production curve) with time along the 23 year period. The trend breaks observed at disaggregate level are indicative of impending changes in the seasonality of NR production in India and Indonesia. Hence, it is imperative to initiate a multidisciplinary investigation to explore the underlying factors influencing the observed pattern of production at aggregate/ disaggregate levels.

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