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Growth Pattern of Rubber Trees (Hevea brasiliensis) in a Tropical Humid Climate in India

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*A study to understand the monthly pattern of growth and its duration in rubber trees [*Hevea brasiliensis *(Willd. ex Adr. de Juss.) Muell. Arg.] was conducted in the traditional rubber-growing zone of India. The climate of the zone is tropical humid type with a dry period of about four months from December to March, and good pre-monsoon showers during March/April. Data were collected on girth growth of trees belonging to 13 clones from an ongoing clone-evaluation trial. Monthly increases in girth, collected for a period of three years from 1992 to 1994 were used to study the growth response of the trees to the ambient environmental conditions. Growth occured in the stress-free period only. Plants started growing from May and continued up to November. Growth increased sharply in the initial monsoon months of May–June, peaked in July–August and declined gradually from September, reaching negligible levels from December to April. In March 1994, a significant number of trees belonging to most of the clones showed a reduction in girth ranging from 0.2 cm to 0.5 cm. From the unweighted pair group-average clustering pattern method, using Euclidian distances, two clusters of homogenous growth trajectories were identified. The growth curves indicated that in the traditional rubber-growing zone in India, *Hevea *had a peak growth period of two months from July to August, and an active growth period of about seven months from May to November.*

Key words: growth pattern; *Hevea brasiliensis*; tropical; humid; climate; India

Rubber [*Hevea brasiliensis* (Willd. ex Adr. de Juss.) Muell. Arg.] is a tree crop originating from the Amazonian rainforests in South America. It is now predominantly grown in South East Asia and Africa at 12° latitude on either side of the equator. This zone presents a warm, humid and equable climate for growth of rubber[1]. In India, rubber is traditionally cultivated in the west coast of the country covering the areas lying in the peninsular India between 8° N and 12° N latitudes. The environmental conditions in this zone are comparatively more congenial for growth and productivity of *Hevea*. Even though the region belongs to the humid tropics, moderate soil moisture stress is experienced annually. Studies on the growth pattern during the immature phase are of fundamental importance in obtaining an insight into the response of trees to the ambient environmental conditions.

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There is a good amount of information on the annual growth patterns, during both the immature and mature phases of the trees[3–8]. A few studies are also available on the monthly growth pattern of *Hevea* trees exposed to long drought and high summer temperatures in the sub-humid tropics[9–11]. However, no study is available as far as the humid tropics is concerned. This study, for the first time, reports the monthly pattern of growth of immature trees of *Hevea* in the traditional rubber growing humid tropical region of India.

MATERIALS AND METHODS

Study Location and Site Features

Data for this study were collected from an ongoing clone-evaluation trial in the traditional rubber-growing zone. The location is the Headquarters of the Rubber Research Institute of India (RRII) at Kottayam (9° 32' N, 76° 36' E, 73 m asl) in the central Kerala region[12]. The site of the trial is a short, west facing slope and the experimental plots covered most of the area. The soil is oxisol with a bulk density of about 1.25 Mg, permanent wilting point at 20% and field capacity of around 27%.

Plant Material and Experimental Layout

Thirteen clones were under evaluation in the trial. These were: RRII 5, RRII 105, RRII 118, RRII 208, RRII 300 and RRII 308 (from India), PR 255 and PR 261 (from Indonesia), RRIM 600 and RRIM 703 (from Malaysia), and SCATC 88-13, SCATC 93-114 and Haiken 1 (from China). Layout of the trial was a randomised complete block design with seven replications. Experimental units consisted of 7 plants in a contour, planted at a spacing of 6.4 m x 3.7 m giving a density of 427 plants per hectare.

Field Planting and Crop Management

Field planting of the trial was carried out during July/August 1989. Three whorled plants raised in polythene bags of 55 cm x 25 cm flat dimensions were used for field planting. Crop management practices, like fertiliser application, weeding, mulching, sun scorch prevention, disease control *etc.* were as per the package of practices recommended for the region.

Plant and Environmental Measurements

Girth of the main stem recorded at monthly intervals from 1992 to 1994 (4th to 6th year after planting) were used to study the growth pattern of *Hevea* trees to the ambient environmental conditions. Girth was measured at a height of 1.5 m from the bud union using a tailor tape calibrated in millimetres and the values were recorded to the nearest 0.1 cm. Meteorological data *viz.*, rainfall, minimum and maximum temperature and sunshine duration for the respective study periods and the preceding ten years were collected from the observatory maintained in the station.

Study of Growth Pattern

Growth pattern of *Hevea* trees was studied by the monthly increases in the trunk girth (circumference). Monthly increases in girth of the trees for each month were obtained by subtracting girth of the previous month from the girth of current month. In each trial and clone, girths of plants of all the replications were used to work out trunk girth averages and monthly increments. Before working out averages, data of plants that became discontinuous due to disease, wind damages and extreme valid outliers were excluded from analysis. By plotting girth increments against months, line graphs were prepared separately for each clone for comparison Mean and generalised growth curves were also drawn

Clustering of Clones Based on Growth Curves

Clustering of the growth curves of the clones with homogenous trajectories was done following unweighted pair group-average method (UPGMA) using Euclidian distances For this purpose a matrix of squared Euclidian distances was worked out using the monthly increment data of all the three years A dendrogram to depict the grouping structure of clones was constructed by subjecting the distance matrix to UPGMA clustering algorithm[13] A mean distance of 1 1 was set for truncation of clusters of similar growth curves

RESULTS AND DISCUSSION

Weather Conditions

The total annual rainfall received in the location during the study periods ranged from 3400 mm to 4000 mm Monthly mean minimum temperature varied from 20°C to 22°C and that of the maximum temperature from 28°C to 36°C The mean maximum temperature in the summer season was around 34°C and in the remaining months it was around 31°C Mean sunshine duration (SSD) was above 8 h day $^{-1}$ in January, February, March and December Mean SSD declined sharply from April to June and was below 4 h day $^{-1}$ in the months from June to November (*Figure 1*) The monthly changes in the parameters during the study periods were comparable with the mean variations in the preceding years

The study location is in the centre of the traditional rubber growing zone of India There are two distinct monsoon seasons namely South-West and North-East The South-West monsoon begins in June becoming more intense in July The wet period from June to September receives excess rainfall The north-East monsoon occurs from October – November and brings in adequate rainfall before withdrawing by mid-November The distribution of rainfall pattern is good The dry period is from December to March and usually does not receive rain In the subsequent period of April and May, thunderstorm activity is common and it brings in good pre-monsoon showers Thus, the stress conditions are normally brief and moderate The climate is humid tropical type and was typical of the location without any unusual deviations during the study period

Growth Pattern

Growth started from May and it continued up to November It increased sharply in the initial monsoon months of May–June, peaked from July–August and declined gradually from September, reaching negligible levels from December to April (*Figures 2 and 3*) Negligible growth was observed in January In March 1994, a significant number of trees belonging to most of the clones showed a reduction in girth ranging from 0 2 cm to 0 5 cm

A little growth observed for the clones during April may not be real but due mainly to the complete restoration of turgor that was lost during the preceding stress period Good growth observed in May was due to the pre-monsoon showers In the subsequent monsoon period, even though most days were predominantly cloudy with limited sunshine hours, girth increase was good suggesting that the plants have received adequate photosynthetically active

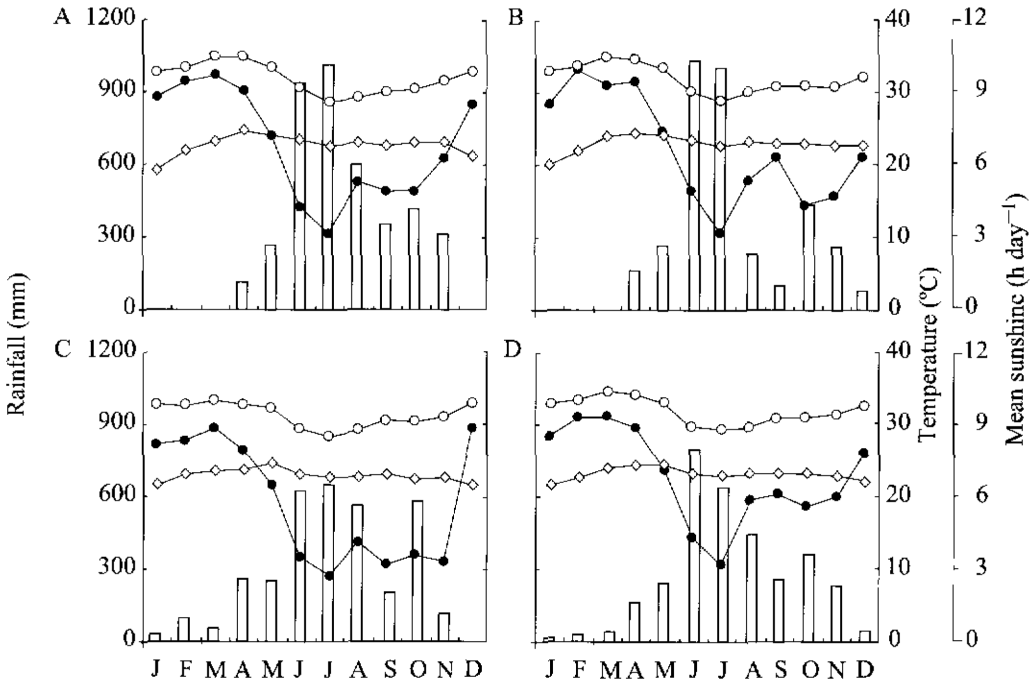
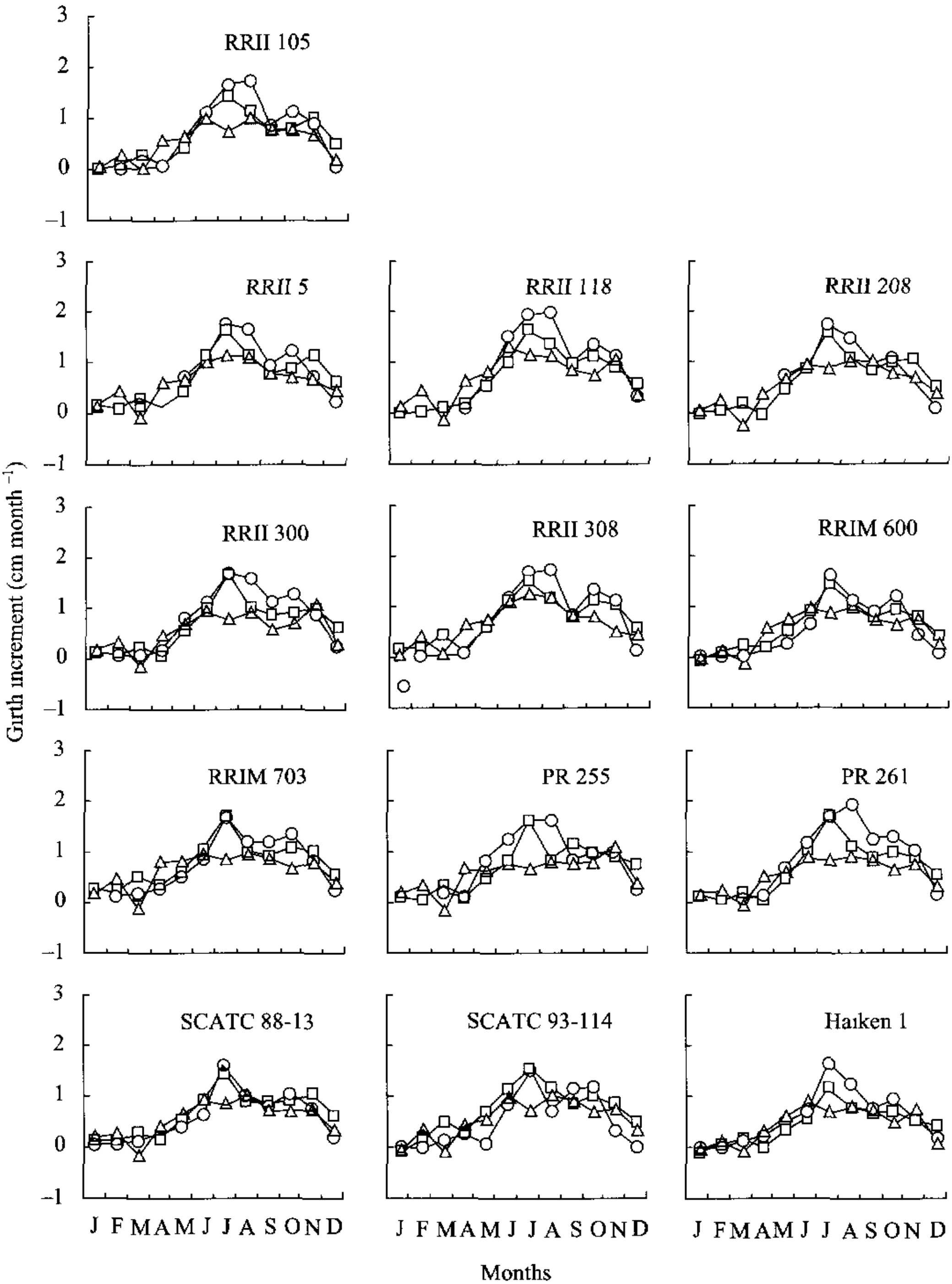


Figure 1. Monthly variations in rainfall (□), minimum (◇) and maximum (○) temperatures and sun shine duration (•) during the years of study (A: 1992; B: 1993; C: 1994) and the preceding ten years including the years of study (D: 1985-94)

radiation. Earlier reports have also advocated similar propositions[9,10]. Continuous good growth of all the clones during May to November was due to the wet conditions existing in those months.

It is well known that temperature and water availability are the two most important constraints for growth and yield of plants. Further, when the ambient temperatures are above optimum, the substrates that could go into growth are increasingly lost through excessive respiration[14]. In the present study, the observed shrinkage in girth of trees in March could be due to soil moisture stress coupled with high temperatures. This type of stem shrinkage resulting from drought and temperature has been confirmed for many species of angiosperm and gymnosperm of the temperate and the tropics[15]. Comparable findings have also been reported in *Hevea*[9–10]. In 1992, though weather conditions were comparable to those of 1993 and 1994, the reduction in girth was either negligible or nil. Therefore it can be presumed that increased leaf area might have contributed to the reduction in girth during the summer months of 1993 and 1994.

Clustering pattern of the clones indicated little difference in growth curves between RRIM 600, SCATC 88-13, RRIM 703, SCATC 93-114 and Haiken 1 and formed the first cluster (*Figure 4*). Similarly RRII 300, PR 261, RRII 5, RRII 208, RRII 105, PR 255, RRII 118



Figures 2 Monthly growth pattern of different clones of Hevea: *(○) 1992, (□) 1993; (△) 1994*

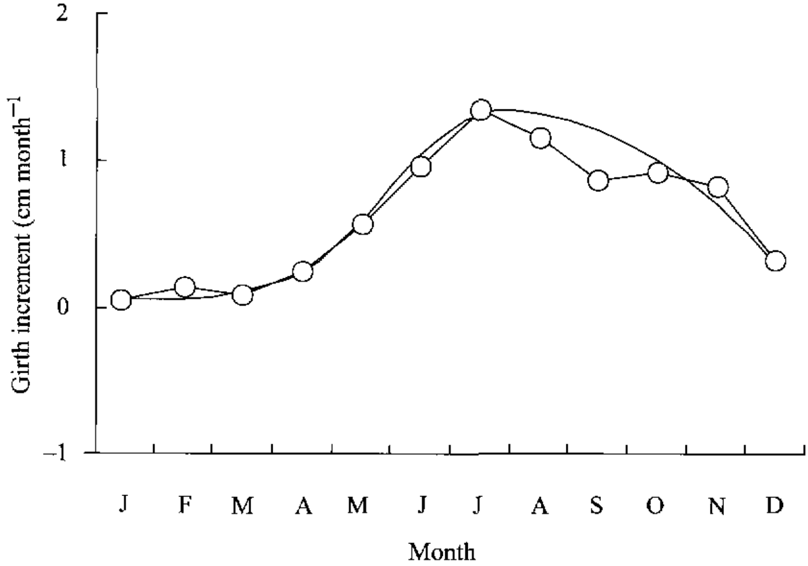


Figure 3. Mean (○) and generalised (—) girth increment curves of Hevea *in the traditional rubber-growing zone in India.*

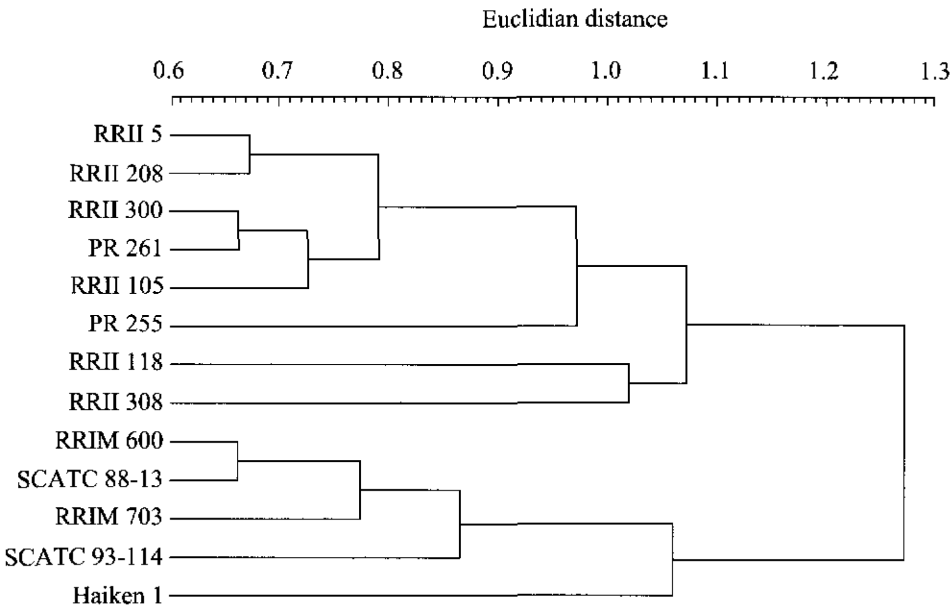


Figure 4. UPGMA clustering pattern of the growth curves of the clones using Euclidion distances.

and RRII 308 formed the second cluster As far as the clustering pattern is concerned, the Chinese and Malaysian clones were clustered in one group and the Indian and Indonesian in the other All the clones were clustered together at a distance of 1 28 The truncation of the clusters at the two-group level appears to provide a good approximation of the similarity of curves The observed clonal variation in the growth pattern could mainly be due to genotypic differences

It is known that the annual growth rate decides the length of pre-production period Studies conducted in a drought prone non-traditional zone of India (North Konkan) have shown that the active growth period of *Hevea* was only three months from July to September, leading to an immaturity period of more than 10 years[10 11], while in the traditional zone it is about 7 to 8 years However, with adequate irrigation the immaturity period in North Konkan could be reduced to six years[11] indicating the importance of rainfall distribution for continuous growth From this study it is clear that the peak growth period of *Hevea* trees in the traditional zone is about two months from July to August and the active growth period is about six months from May to October and the extended growth period is the reason for the reduced immaturity period in this zone

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