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SEASONAL PERFORMANCE OF THREE ELITE HEVEA - RUBBER CLONES IN A LESS FAVOURABLY SUITED EDAPHIC AND CLIMATIC CONDITIONS OF ORISSA

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ABSTRACT

Effect of seasonal changes on the growth and yield performance of three elite *Hevea* clones (RRII 105, RRIM 600 and GT 1) were studied in the warm dry sub humid region of Orissa. The soil characters are only marginally suited, when compared to that of traditional belt of rubber growing areas. This is a non-traditional rubber growing area, where the crop experiences severe drought in summer months. Prolonged soil moisture stress, high wind speed and high summer temperature are the major environmental constraints affecting the growth of rubber in this region. The relative growth rate declined drastically in all the elite clones with increase in age of the plants. The mean annual girth increment was 4.4cm. Highest girth increment was recorded in RRIM 600 closely followed by GT 1 and RRII 105. Maximum growth was recorded during post monsoon (September-November, 53 per cent) followed by monsoon season (June-August, 33 per cent), while lowest growth was observed during summer (March-May, 6 per cent). In spite of life saving irrigation in summer, the seasonal growth was low in the dry sub-humid region of Orissa. In general, RRIM 600 maintained relatively higher seasonal performance. RRIM 600 recorded highest dry rubber yield (24.8 g/tree/tap) over the first two years of tapping followed by RRII 105 (22.0 g/tree/tap) and GT 1 (18.2 g/tree/tap). The mean commercial projected yield of RRIM 600 is 992 kg/ha/400 trees, followed by RRII 105 (880 kg) and GT 1 (728 kg). An attempt was also made to study the influence of seasonal hydro-meteorological parameters like temperature, relative humidity, rainfall evaporation and sunshine hours on the growth and yield of rubber in this region. Correlation and regression of seasonal RGR with climatic parameters are discussed in this paper.

INTRODUCTION

Rubber (*Hevea brasiliensis*) a native forest tree species of the Amazon region, is now being cultivated in different agro climatic zones even though optimum conditions are not available. The traditional region of rubber cultivation in India is the Southern part of west coast extending from Kanyakumari (8°15'N) to Mangalore (12°52"N). This stretch of land is characterized by fertile soils rich in organic matter and receives fairly high rainfall during two distinct monsoon seasons (Jacob *et al.*, 1999). This region offers ideal environmental conditions with a mean annual temperature of 28° ± 2° C and a well distributed rainfall of 2000-4000 mm, extending from 100-150 days in a year (Pushparajah, 1983).

In order to meet the growing demand of natural rubber, its cultivation has been extended to less suitable non-traditional areas like Orissa, North Konkan, Assam, Meghalaya and Tripura etc, where climatic conditions and other related environmental factors are different from the traditional rubber growing areas (Sethuraj *et al.*, 1991). In the eastern part of India (Orissa region) there are prolonged dry spells of seven to eight months in a year and consequently the rubber clones have to face severe stress condition during that time (Sethuraj *et al.*, 1991; Gupta and Edathil, 2001). The major constraints is expanding rubber cultivation to these warm dry sub-humid regions are prolonged drought coupled with high ambient day temperatures during the summer months, low relative humidity and dry wind (Mohankrishna *et al.*, 1991 Meenattoor *et al.*, 2000). Under these conditions, even after providing life saving irrigation, rubber plantations exhibit growth inhibition leading to longer gestation period (Vijaya Kumar *et al.*, 1988 and Sethuraj *et al.*, 1991). Preliminary reports are available on the growth performance of *Hevea* from the eastern region of India (Meenattoor *et al.*, 2000 and Gupta *et al.*, 2001b), but so far no work has been carried out to study the effect of seasons on the growth performance of *Hevea* clones in Orissa. Hence, the present study was undertaken to find out the influence of seasonal variations on the performance of three elite clones of Hevea (RRII 105, RRIM 600 and GT 1) and also to identify clone suitable to this region.

MATERIALS AND METHODS

The experiment was laid out during 1987-88 at the Rubber Research Institute of India's

Regional Research Station Kadalipal (Dhenkanal), located at 20°49'40" N latitude, 85° 30'45"E Longitude and altitude of 100m MSL in Orissa. The soil characters of rubber areas prevailing in Eastern India (Table 1) can be stressful to *Hevea*. The experimental field has a gentle slope. The soil type is an Alfisols order with pH 5.5 having bulk density 1.60 Mg/m³ of sandy loam type and is of lateritic in nature. The initial fertility status of the experimental site showed that the soil was low in organic carbon (0.05%), available phosphorus (0.5 mg/100g of soils) and potassium (3.13 mg/100g of soils). The available Mg was in the high range i.e. 2.58 mg/100g of soils. The available soil moisture field capacity was 15.1 per cent and permanent wilting point 8.8 per cent. Low availability of moisture in the soil is likely to create stress in different seasons. In this experiment three elite clones (RRII 105, RRIM 600 and GT 1) were planted in Randomized block design with 36 plants/plot in eight replications. Budded stumps were used as planting material and field planted at 4.6 m x 4.6 m spacing. During subsequent years, plants in some plots suffered casualties due to unfavourable climatic conditions and the same were filled-up. The plants were raised following all cultural practices recommended for the traditional rubber growing region. In the initial years, partial life saving irrigation was provided in summer months. Growth was recorded as girth of the trunk at a height of 125 cm above the bud union. Girth and girth increment (GI) were recorded at regular intervals from December, 1991 to November 1997 and the data on biomass of all clones were computed following the equation of Shorrocks *et al.*, (1965).

Equation: Biomass (kg) = $0.002604\ G^{2.7826}$

where, G is the girth in cm.

Seasonal Relative growth rate (RGR) was calculated from biomass changes. The weather parameters viz. rainfall, number of rainy days, maximum temperature (Max.T), minimum

Table 1. Soil characteristics of rubber cultivated areas in traditional and non-traditional region

Sl No.	Parameter	Traditional region (Kerala)	Non-traditional region (Orissa-Eastern India)
1.	Soil type/ Topography	Ultisol, gentle slope to hilly terrain	Typic Haplustals, Alfisols, plain to gentle slope, sandy loam gravelly
2.	Nature of soil	Lateritic soils, well drained	Lateritic soils, murrum, and rock Yellowish, red very strongly acid sandy loam horizons, well-drained
3.	pH	5.0	5.5
4.	Organic carbon (%)	2.01	0.05
	<u>Available nutrients</u> (mg/100g soil)		
5.	P	0.63	0.50
6.	K	1.82	3.13
7.	Mg	1.46	2.58
8.	Coarse sand (%) Fine sand (%)	33.9 7.0	43.2 30.0
9.	Silt (%)	9.1	18.8
10.	Clay (%)	50.0	8.0
11.	Field capacity (%)	16-32	15.1
12.	Permanent wilting point (%)	6.5-24	8.8

temperature (Min.T), sunshine hours (SsH) evaporation (Ev), relative humidity (RH) were collected from the agromet observatory at the Regional Research Farm, Kadalipal. Regression equations and correlation between seasonal RGR and all the relevant weather parameters were worked out. In order to assess the influence of various seasons on the *Hevea* growth, twelve months in a year were grouped as four seasons (**winter**-December to February, **summer**-March to May, **monsoon**-June to August and **post monsoon**-September to November) based on these hydrometeorological parameters in the region (Table 2).

Tapping was started in 1997 and trees were tapped following 1/2S d/2 6d/7 system. After the onset of tapping, girth was measured at a height of 150 cm above the bud union. Dry rubber yield (gram/tree/tapping) was recorded twice a month and the pooled yield data for two regular years of tapping (July to March) were recorded following cup coagulation method. Seasonal data on girth and girth increment were analysed (Table 3) and depicted in Fig.3. The annual girth as on March 2001 and initial yield (pooled for two years) were analyzed following standard statistical procedures.

RESULTS AND DISCUSSION

Seasonal variations (mean of 6 seasons from December 1991 to November 1997) in rainfall, number of rainy days, evaporation, air temperature (maximum and minimum) bright sun shine hours and relative humidity are presented in table 2.

The annual total rainfall of RRS Farm, Kadalipal (Dhenkanal) is about 1097 mm, but nearly 64 per cent of it is received during monsoon period (June-August), least during winter (December-February-2%). This is one of the contributing factors for severe moisture stress during the major part of the year (Table 2 and Fig.1). There were only 68 rainy days in a year and out of which 42 days was during the monsoon period and hence the typical uni-model distribution of rainfall. The minimum rainfall required for rubber cultivation is 1500 mm but the preferred average is 2500-4000 mm with a total of 100-150 rainy days per year (Pushparajah, 1983). The initial rains received after the summer season recharged the soil and subsequent heavy rainfall in monsoon resulted in surface run off and deep percolation because of the nature of the soil (Table 1). The basic infiltration rate (BIR) is in between 100-120 mm/hour under cashew and rubber plantations. The cumulative infiltration value was in between 500-600 mm under cashew and rubber, respectively (Varadan *et al.*, 2000). Generally, in this region the rainfall recedes in October and the dry spell continues for 6-7 months and the soil moisture depletes below the wilting point (Gupta *et al.*, 2001a).

The annual growth (girth increment) and relative growth rate (RGR) are presented in Fig.2 (a & b). The RGR declined drastically in all the elite clones with increase in age of the plant (Templeton, 1968; Dey *et al.*, 1998). The average growth increment was 4.4 cm (Table 3). Highest mean

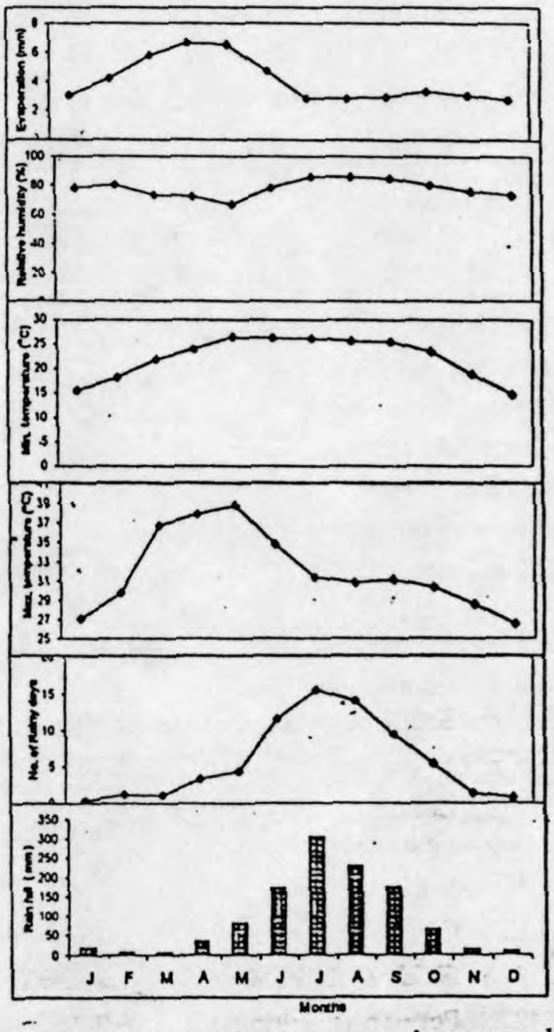

Fig. 1. Monthly weather parameters in a warm dry sub-humid region (Orissa), 1991-97

girth increment (GI) was recorded in RRIM 600 closely followed by RRII 105 and GT 1. Growth during monsoon and post monsoon seasons was higher and declined subsequently. It constituted 33 per cent and 53 per cent of the annual GI, compared to 6 per cent and 8 per cent during summer and winter seasons respectively (Fig. 3). This is reflected in the higher growth (GI) observed in the post monsoon (0.8 cm/month) and monsoon season (0.5 cm/month). The lowest was observed

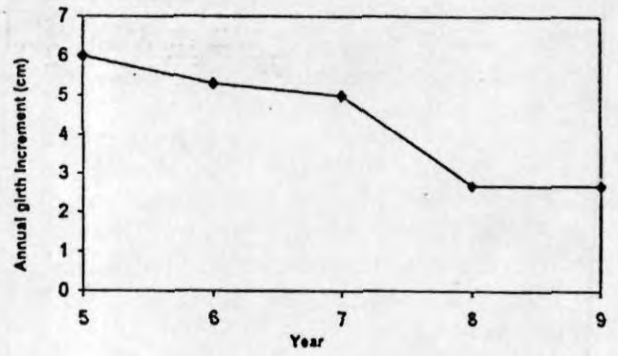

Fig. 2 a. Annual girth increment in warm dry sub-humid region of Orissa

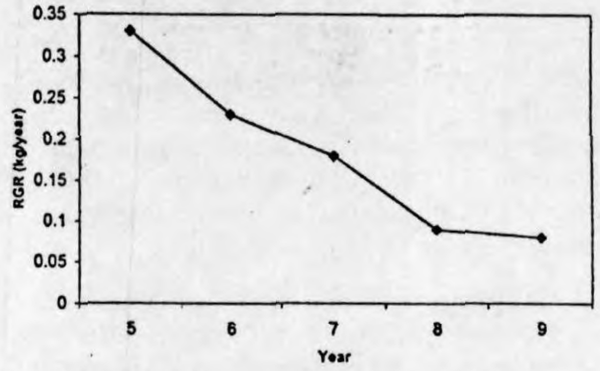

Fig. 2 b. Relative growth rate (RGR) in warm dry sub-humid region of Orissa

Table 2. Seasonal hydrometeorological parameters at RRS Farm, Kadalipal (Dhenkanal) (Mean of 6 seasons 1991-1997)

Parameter	Season				
	Winter (Dec-Feb)	Summer (Mar-May)	Monsoon (Jun-Aug)	Post monsoon (Sep-Nov)	Annual Mean 6 yrs
Rainfall (mm)	023.9	119.8	703.3	250.0	1097.0
No. of Rainy days	2.0	9.0	42.0	15.0	68.0
Evaporation (mm/day)	3.3	6.3	3.4	3.0	4.0
Air temperature (°C)					
Maximum temp.	27.7	37.8	32.3	30.0	31.9
Minimum temp.	16.0	24.0	25.9	22.5	22.1
Sunshine hours	8.5	9.4	6.1	7.0	7.7
Relative humidity(%)	77.0	70.0	84.0	81.0	78.0

Table 3. Seasonal girth and girth increment of elite clones in less favourably suited edaphic and climatic conditions of Orissa (Mean of 6 seasons 1991-1997)

Parameter	Season girth(cm) and girth increment(cm)*				
	Winter	Summer	Monsoon	Post monsoon	Mean
RRII 105	27.8	28.1(0.3)*	29.4(1.3)	32.1(2.7)	29.4(4.3)
RRIM 600	31.6	31.9(0.3)	33.7(1.8)	36.2(2.5)	33.4(4.6)
GT 1	29.9	30.2(0.3)	31.7(1.5)	34.1(2.4)	31.5(4.2)
Mean	29.7	30.0(0.3)	31.6(1.6)	34.1(2.5)	31.4(4.4)

* Figures in bracket indicate girth increment (cm).

in summer (0.1 cm/month). In spite of life saving irrigation in summer, seasonal growth was low in this season (Fig 3). Growth inhibition was earlier reported by Saengruksowang *et al.*, (1983), when rubber was cultivated in a climate having distinct dry season in Thailand. Growth of GT 1 reduced significantly under dry condition of Ivory Coast (Omont, 1982). Rubber plants need a threshold temperature of 22 - 25° C for optimum growth and at 10° C air temperature ceasing of photosynthesis has been reported (Zongdao and Xueqin, 1983). Under rainfed conditions, the immaturity period was around nine to ten years in dry sub humid regions of India (Chandrashekar *et al.*, 1990) and also in warm dry sub humid region (Gupta and Edathil, 2001). Earlier, it has been reported that 70-80 per cent growth was observed during June to November and growth retardation during winter months in non-traditional regions of North East India (Sethuraj *et al.*, 1991). During the summer season, the growth of RRII 105 was poor and similar reports have been made by Meti *et al.*, (1999) and Sethuraj *et al.*, (1991). Among the elite clones, RRIM 600 and GT 1 showed more stability in growth compared to other clones, indicating their greater flexibility in adapting to the different environments (Meti, *et al.*, 1999).

Generally, a clone is opened for commercial exploitation if 70 per cent of the trees of a particular clone attain 50 cm girth at a height of 125 cm from the bud union. Therefore, from the basis of the growth and percentage of tappability attained, the clones GT 1 (30.0%) and RRIM 600 (27.2%) performed better than the other clone RRII 105 (12.3%) after 9th year of planting (Table 4).

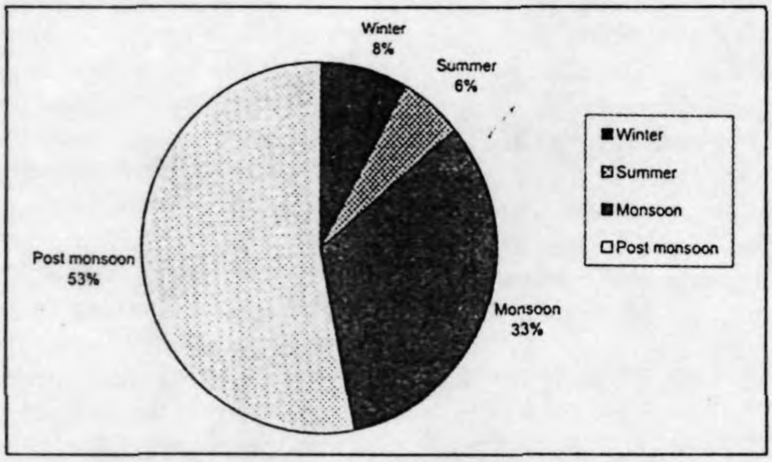

Fig. 3. Seasonal growth performance of Elite clones in Orissa

Table 4. Annual variability in mean girth, girth increment, tappability percentage and yield of rubber

Clone	Mean girth at commencement of tapping (cm)	Tappability (%)	Annual girth increment on tapping (cm)	Mean girth in March 2001 (cm)	Rubber mean yield(g/t/tap)[1]	Projected yield (kg/ha/year)*
RRII 105	38.1	12.3	3.7	52.7	22.0	880
RRIM 600	42.8	27.2	3.5	56.8	24.8	992
GT 1	40.6	30.0	4.3	57.6	18.2	728
General mean	40.5	23.1	3.8	55.7	21.7	866
CD(P=0.5)	--	--	--	2.5	4.3	171

[1] - Rubber mean yield (pooled for two regular years tapping)

* - Commercial yield projected based on 400 trees in 100 tapping days/ha/year.

Chandrashekar *et al.*, (1998) reported that in non-traditional area at Dapchari in Konkan region of Maharashtra, only 12.5 per cent of plants achieved tappable girth in Clone evaluation trial after 9 years of planting. Among the elite clones, GT 1 exhibited better girth increment on tapping (4.3 cm) followed by RRII 105 (3.7 cm). RRIM 600 had shown lesser girth increment on tapping, when compared to other clones (Table 4).

Initial mean dry rubber yield recorded by RRIM 600 (24.8 g/t/tapping) was significantly superior to GT 1 (18.2g/t/t), on par with RRII 105 (22.0 g/t/t). The high yielding character of RRIM 600 was reported earlier by Chandrashekar *et al.*, (1990) and Meenattoor *et al.* (1991). Considering the performance of clones in terms of productivity (Table 4), RRIM 600 recorded the highest mean yield of 992 kg/ha/year, significantly superior to GT 1 (728 kg/ha/year) over the initial two regular years of tapping. However, RRII 105 (880 kg/ha/year) was on par in yield with RRIM 600. This may be due to the deeper and denser root system of RRIM 600, which may be responsible for maintaining higher plant moisture status during the stress periods. The indirect evidence of water absorption by *Hevea brasiliensis* from deeper layers of soil have also been reported (Monteny *et al.*, (1985).

Correlation and regression of seasonal RGR with weather parameters are presented in Table 5. Seasonal RGR showed positive correlation with rainfall and relative humidity, which indicates that rubber requires high rainfall and high humidity for its growth and related physiological processes. Dry air severely affects the stomatal conductance and transmission rate in dry sub humid region of Konkan region (Chandrashekhar, *et al.*, 1990) and thus ultimately the growth is affected. Seasonal RGR showed positive relation with minimum temperature during post monsoon. Maximum and minimum temperatures are to major climatic factors affecting the plant growth. Sanjeev Rao and Vijay Kumar (1992) observed that *Hevea* requires a mean monthly air temperature ranging from 25-28° C for its optimum gorwth. In the present study, it was observed that both minimum and maximum temperatures were lower than the required level during the winter season, whereas it was higher during the summer season. Thus, all the elite clones showed retarded growth (Fig. 3) and prolonged immaturity period in this region. Low growth during winter is associated with low soil temperature (Saseendran, *et al.*, 1993). However, during the post monsoon season the air temperature was in the optimum range, thus correlating to better growth and RGR during this season. High temperature results in high rates of evaporation leading to severe soil moisture stress (Table 2), causing injury to leaves and affecting stomatal conductance in this warm dry sub humid climate. Similar report has been given by Chandrashekar *et al.* (1990).

Seasonal evaporation (Ev) and sun shine hours (SsH) had negative relation with seasonal RGR, which indicates that high sunshine hours during summer along with low soil moisture (Ev) is detrimental to growth. Moneteny *et al.* (1985) reported that low moisture availability and a weak surface to air water vapor gradient, the evapo-transpiration rate is reduced progressively by the closure of stomata and thus affecting the photosynthesis activity and thereby adversely affecting the growth of the plants. The data that are non-significant are not presented in the Table 5. The results of the present study clearly indicated that though the sunshine hours were high in the warm dry sub humid region of Orissa, the growth was low because of other limiting factors such as water scarcity. In the absence of any other limiting factors, increaseed solar radiation will have a beneficial effect on the plant growth (Dey, *et al.*, 1998). Positive relation of RGR with seasonal rainfall and relative humidity indicated that the rainfall is the prime factor. The major growth period of *Hevea* was recorded during post monsoon and monsoon seasons, which was due to the conducive environmental factors prevailing in this region. The minimal growth in dry season and negative relation of seasonal growth with maximum temperature, Ev and SsH indicates that more sunshine hour with high temperature and evaporation is detrimental to the growth of rubber. Among the elite clones, RRIM 600 showed better seasonal growth and initial yield performance, indicating it's comparatively better adaptibility in a less favourably suited edaphic and climatic conditions of Orissa.

Table 5. Regression equations for seasonal relative growth rate (Y) vs. seasonal hydro-meteorological parameters in Orissa

Parameter	Regression equation	r-value
Rainfall	$Y = 0.015 + 2.15 \times 10^{-5}$ (RF)	0.84*
Relative humidity	$Y = 0.434 + 0.005$ (RH)	0.82*
Maximum temperature	$Y = 4.37 - 0.230$ (Max T) + 0.003 (Max T^2)	-0.92*
Minimumtemperature	$Y = -11.519+2.32$ (Min T) -0.144 (Min T^2)	0.92*
Evaporation	$Y = 1.262-0.713$ (Ev) + 0.102 (Ev^2)	-0.88*
Sunshine Hours	$Y = -979.4+413.7$ (Ssh) - 58.2 (Ssh^2)	-0.98*

* Significant at $P \leq 0.05$, Number of observations = 24.

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