RESEARCH ARTICLE

GROWTH PERFORMANCE OF RUBBER (*HEVEABRASILIENSIS* MUELL. ARG.) PLANTATION IN HILLY ZONE OF KARNATAKA

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Abstract: The objective of this experiment was to assess the influence of site factors on growth and productivity of *Hevea brasiliensis* clone RRII 105in different aged rubber plantation in Hilly zone of Karnataka. Hilly zone was classified into two ecological zones based on annual rainfall distribution *viz.,* Mundgod (798 mm) and Sagara (1918 mm).Seasonal diameter increments during monsoon (June-September) and winter (October-December) was higher and declined subsequently in summer (January-March) in all age gradation. The volume production and productivity was observed to be double in Sagara for all the age gradation in comparison with Mundgod due to maximum DBH, tree height, favourable climatic conditions, moderate soil fertility status and lesser temperature extremes prevailing in zone.

Keywords: Age,girth increment, Productivity, Site factor, Hilly zone

INTRODUCTION

Rubber (*Hevea brasiliensis* Muell. Arg.) is indigenous to Amazon basin and is one of the major industrial crop grown mainly in tropical climate between 12º latitude on either side of equator. In India, it is largely cultivated in the humid tropical zone between 8º 15′ N and 12º 52′ N latitudes. Mature *Hevea* trees in native habitat are about 25-30 metre tall with an average diameter at breast height (DBH) greater than 1 metre. Potential use of rubberwood was initially identified at Forest Research Institute in 1953 and now rubberwood is widely planted for the production of timber.

The deviating climate, consisting of sets of weather attributes along with gaseous distribution (ozone, CO_2 etc.,) and biotic potential over years, brings about erratic/unpredictable environment that imposes stress on growth and productivity of plants. The fact that acclimatization of *Hevea* to non-indigenous climate, especially stress prone areas like low temperature, high altitude, high windspeed *etc.,* of China resulted in profitable returns (Guohua and Haiping, 2005) but areas having high temperature and low rainfall might bring adverse social and economic impact where rubber cultivation would be non-recommendable.

Studies on growth are of fundamental importance in understanding the interaction between plant and their environment conditions. Data relating to changes in plant morphology to plant age can be useful in studies dealing with modelling long term growth. The aim of this work was to present an analysis of growth and productivity during immature, juvenile and early mature phase of *Hevea* trees in two contrasting ecological zone for understanding the scope of rubber cultivation in Hilly zone of Karnataka.

MATERIAL AND METHOD

The present study was conducted in established plantation of *Hevea brasiliensis* in Mundgod (14^0 12' 390" N Latitude and 75^0 11" 580" E Longitude) and Sagara (14^0 13' 355" N Latitude and 75^0 11' 635" E Longitude) of Uttara Kannada and Shivammoga district, respectively. The site was divided in relation to rainfall *viz.,* Low rainfall (Mundgod) and high rainfall (Sagara) of 798 mm and 1915 mm, respectively during the study period. Plantation of three age gradation*i.e.* 4 year (immature), 7 year (Juvenile) and 10 year (early mature) with uniform spacing of 3.5 x 4.2 m were located in each site. Due care was taken to choose sub plot under similar situation of respective main plots.

Enumeration of *Hevea* stands was carried out in randomly selected plantation. Four quadrates of size 20 x 20 m were laid out randomly in each plantation to measure diameter at breast height, total height, form factor for estimation of volume production and productivity in each quadrat. The data on growth and productivity were subjected to statistical analysis by ANOVA (analysis of variance) using DMRT (Duncan's Multiple Range Test) to ascertain significance of various growth parameters using SPSS version 22 at five per cent significance level (p = 0.05).

RESULT AND DISCUSSION

A comparison made with similar age plantation across different ecological zones exhibited statistically significant difference with respect to all the growth attributes and productivity. Though the rainfall is rather high in Sagara (1915 mm with 132 rainy days) its distribution is highly skewed with rains mostly concentrated during months from June to September. North east monsoon showers are

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limited and summers were relatively dry. Temperature and relative humidity were also high but adequate to this region.On the contrary, Mundgod region received an annual rainfall of 798 mm with low number of rainy days. The distribution of rainfall is far from satisfactory which results in long dry spells extending from November to March, due to which region experiences severe seasonal drought (Table 1). High atmospheric heat load and vapour pressure deficit with soil moisture conditions near wilting point create adverse conditions for the growth of *Hevea*.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 (Krishnan, 2015).

Growth attributes

Tree height and diameter varies between plantations of particular age and is strongly influenced by site factors. In Sagara region, tree height and diameter showed statistically higher growth varying from 5.52 m at 4 year to 12.08 m at 10 year and 10.66 cm at 4 year to 18.47 cm at 10 year, respectively. Whereas, tree height and diameter in Mundgod region showed variation from 4.26 m at 4 year to 8.92 m at age of 10 year and 8.67 cm at 4 year to 12.13 cm at 10 year. These variations recorded between ecological zone may be due to difference in climatic and edaphic factors prevailing in respective location (Table 2 and 3).

Seasonal growth pattern of *Hevea brasiliensis*

Good girth is an important attribute for sustained yield and girth increment is widely used in *Hevea*cultivation as a parameter of growth, particularly during the immaturity period (Shorrock *et al.,* 1965). *Hevea* clone, RRII 105 showed very limited difference in seasonal diameter increment between the two ecological zone. Seasonal diameter increment during monsoon (June-September) and winter (October-December) was higher and declined subsequently in summer (January-March) in all age gradation.

Monsoon coupled with lifesaving irrigation in immature phase (4 year) during monsoon recorded highest seasonal diameter increment of (1.03 cm), (0.82 cm) in Sagara and Mundgod region respectively. While, in juvenile phase (7 year) and early mature phase (10 year), reduction in seasonal diameter increment was observed which may be due to inappropriate practice of tapping observed in sixth year in non-traditional belt of Karnataka (Fig 1).

However, between two ecological zones, Sagara recorded highest annual diameter increment in age gradation of 4 year (1.99 cm), 7 year (1.49 cm) and 10 year (1.15 cm) which may be due to adequate monsoon showers, lesser temperature variations, optimum relative humidity and compound interest effect of the previous growth. While, Mundgod recorded comparatively lower annual diameter increment in age gradation of 4 year (1.48 cm), 7 year (1.06 cm) and 10 year (0.8 cm) which may be due to low rainfall and high temperature variation prevailing in Mundgod (Fig 2 and 3).This trend was in agreement with the reported literature by Krishnan (2015), Chandrashekhar (2003) in *Hevea brasiliensis*.

Volume production and productivity

Hevea brasiliensis plantation of Sagara region at 4, 7 and 10 year recorded maximum volume production of 18.44 m^3/ha, 57.65 m^3/ha and 119.05 m^3/ha, respectively due to favourable climatic and edaphic conditions coupled with soil nutrients that enhanced better growth, resulting in higher volume production. However, significantly lower volume production of 9.39 m^3/ha, 30.82 m^3/ha and 66.70 m^3/ha was recorded at 4, 7 and 10 year plantation, respectively in Mundgod which may be due to climatic variation condition prevailing in Mundgod, resulting in long dry spell (Table 5).

The productivity of *Hevea brasiliensis* plantation in Sagara was almost double the productivity recorded in Mundgod zone. Higher productivity in Sagara for age gradation of 10 year followed by 7 and 4 year may be attributed to maximum DBH, tree height, favourable climatic conditions, moderate soil fertility status and lesser temperature extremes. On the contrary, comparatively lower performance of *Hevea brasiliensis* plantation in Mundgod could be attributed to climatic variation resulting in lower productivity (Table 6).

Table 1. Average meteorological data of Mundgod and Sagara region.

Sl. No	Particulars	Mundgod	Sagara
1.	**Annual rainfall (mm)**	798	1915
2.	**Number of rainy days**	77	132
3.	**Maximum temperature (^{0}C)**	32.0 ºC	29.5 ºC
4.	**Minimum temperature (^{0}C)**	19.5 ºC	18.0 ºC
5.	**Relative humidity (%)**	69	72

Table 2. Mean tree height (m) of rubber plantation as influenced by age gradation and site condition

Main plot (M)/ Sub plot (S)	Mean tree height (m)		
	4 YAP	**7 YAP**	**10 YAP**
Mundgod	**4.26^{cB}**	**7.23^{bB}**	**8.92^{aB}**
Sagara	**5.52^{cA}**	**9.18^{bA}**	**12.08^{aA}**
F value (M)	5375.36*	p (M)	<0.05
F value (S)	12672.74*	p (S)	<0.05
F value (M x S)	372.76*	p (M x S)	<0.05

**Significant at 5 % level.*
Means having same letter as superscript indicate they are homogenous (on par) row wise
Means having same letter as superscript indicate they are homogenous (on par) column wise

Table 3. Mean diameter at breast height (cm) of rubber plantation as influenced by age gradation and site condition

Main plot (M)/ Sub plot (S)	Mean DBH (cm)		
	4 YAP	**7 YAP**	**10 YAP**
Mundgod	**8.67^{cB}**	**12.13^{bB}**	**16.10^{aB}**
Sagara	**10.66^{cA}**	**14.72^{bA}**	**18.47^{aA}**
F value(M)	13955.31*	p (M)	<0.05
F value (S)	50386.06*	p (S)	<0.05
F value (M x S)	78.45*	p (M x S)	<0.05

**Significant at 5 % level.*
Means having same letter as superscript indicate they are homogenous (on par) row wise
Means having same letter as superscript indicate they are homogenous (on par) column wise

Table 4. Mean basal area (m^2/ha) of rubber plantation as influenced by age gradation and site condition

Main plot (M)/ Sub plot (S)	Mean basal area (m^2/ha)		
	4 YAP	**7 YAP**	**10 YAP**
Mundgod	**4.03^{cB}**	**7.87^{bB}**	**13.85^{aB}**
Sagara	**6.10^{cA}**	**11.59^{bA}**	**18.22^{aA}**
F value(M)	10232.04*	p (M)	<0.05
F value(S)	35982.24*	p (S)	<0.05
F value (M x S)	418.44*	p (M x S)	<0.05

**Significant at 5 % level.*
Means having same letter as superscript indicate they are homogenous (on par) row wise
Means having same letter as superscript indicate they are homogenous (on par) column wise

Table 5. Mean volume production (m^3/ha) of rubber plantation as influenced by age gradation and site condition

Main plot (M)/ Sub plot (S)	Mean volume production (m^3/ha)		
	4 YAP	**7 YAP**	**10 YAP**
Mundgod	**9.39^{cB}**	**30.82^{bB}**	**66.7^{aB}**
Sagara	**18.44^{cA}**	**57.65^{bA}**	**119.05^{aA}**
F value (M)	14002.44*	p (M)	<0.05
F value (S)	34246.90*	p (S)	<0.05
F value (M x S)	2556.78*	p (M x S)	<0.05

**Significant at 5 % level.*

Means having same letter as superscript indicate they are homogenous (on par) row wise
Means having same letter as superscript indicate they are homogenous (on par) column wise

Table 6. Mean volume productivity (m^3/ha/yr) of rubber plantation as influenced by age gradation and site condition

Main plot (M)/ Sub plot (S)	**Mean volume productivity (m^3/ha/yr)**		
	4 YAP	**7 YAP**	**10 YAP**
Mundgod	**1.86^{cB}**	**3.85^{bB}**	**6.14^{aB}**
Sagara	**3.68^{cA}**	**7.20^{bA}**	**10.82^{aA}**
F value (M)	6459.77*	p (M)	<0.05
F value (S)	6498.80*	p (S)	<0.05
F value (M x S)	408.98*	p (M x S)	<0.05

**Significant at 5 % level.*
Means having same letter as superscript indicate they are homogenous (on par) row wise
Means having same letter as superscript indicate they are homogenous (on par) column wise

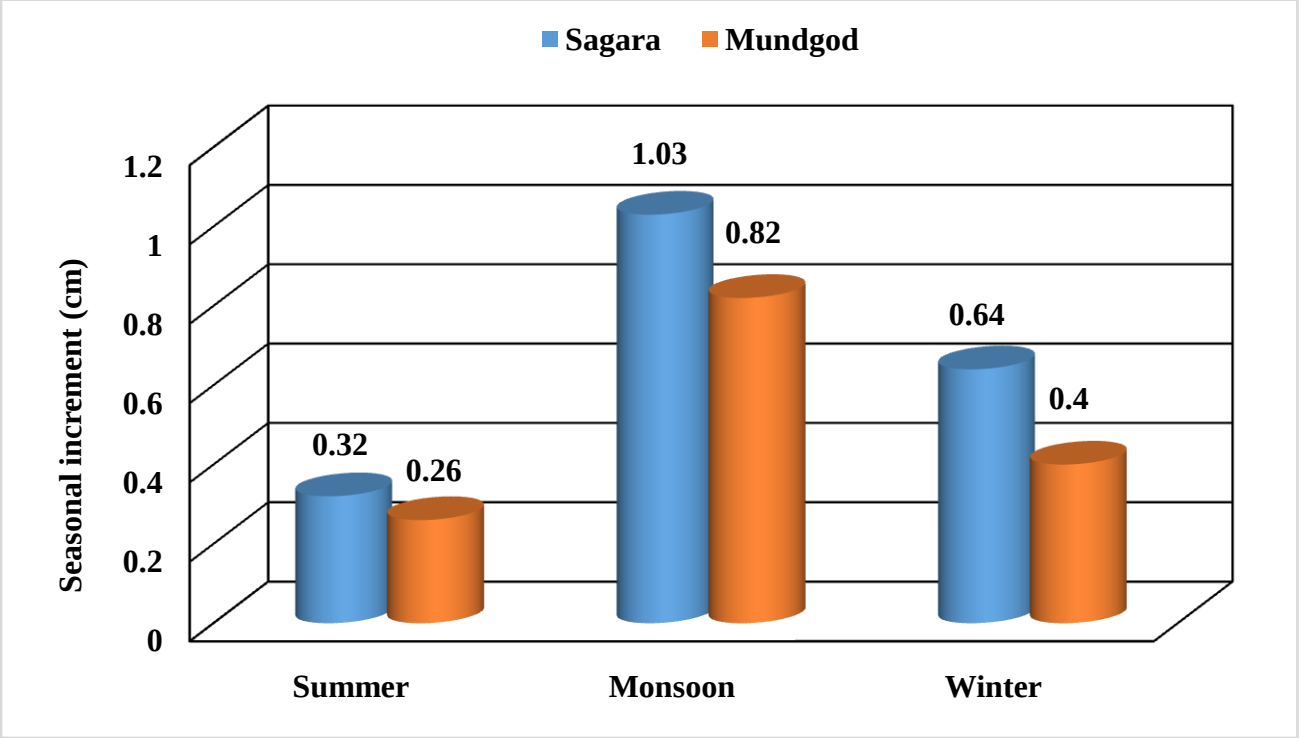

Fig. 1. Mean seasonal diameter increment (cm) of rubber plantation in immature phase (4 year)

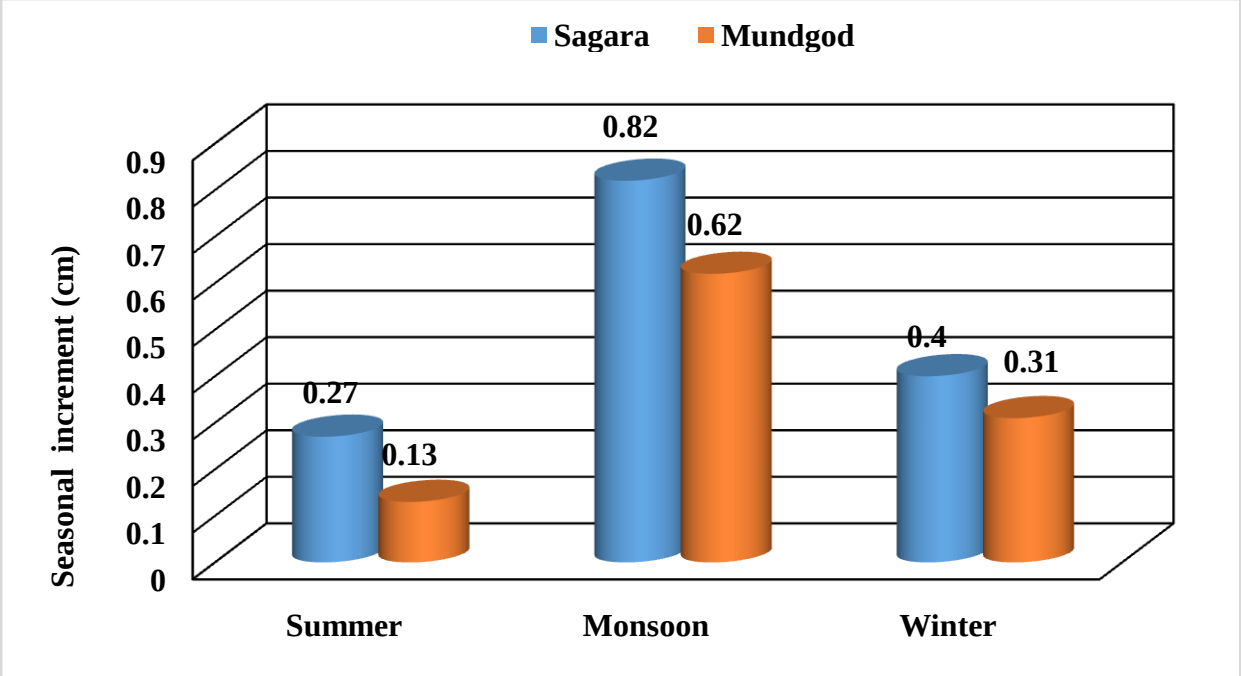

Fig. 2. Mean seasonal diameter increment (cm) of rubber plantation in juvenile phase (7 year)

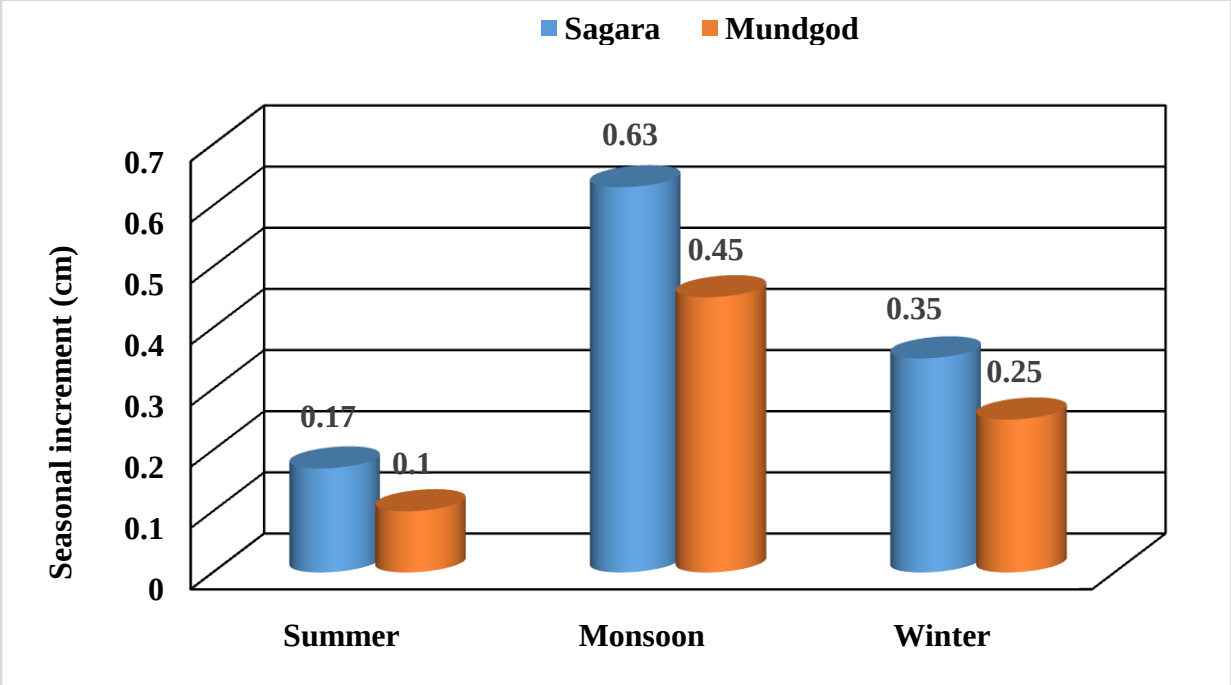

Fig. 3. Mean seasonal diameter increment (cm) of rubber plantation in early mature phase (10 year)

CONCLUSION

It can be concluded from present study, temperature and water availability are most important constraint for growth and productivity of *Hevea* and it can be conveniently raised in Sagara zone. RRII 105 was proved to be unsuitable for growing in drought prone conditions in this era of climate change. Genotype environment interactions (GEI) studies could pave way in identifying best suited clones for dry conditions. Also, a rubber based agroforestry system as opposed to rubber monoculture would be an excellent option and is recommended, as it could improve the productivity and economic feasibility for livelihood of farmers.

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