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GROWTH AND YIELD PERFORMANCE OF SEVEN POPULAR *Hevea* CLONES AND SOIL PROPERTIES IN SUB-TROPICAL AREAS OF MIZORAM

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Abstract: *This study was conducted at the Regional Research station of Rubber Research Institute of India at Tuichhuhen farm in Kolasib district of Mizoram. Mizoram in the north-eastern Himalayas lies between 22^0 00` and $24^0$15` N and $92^0$20` and $93^0$29` E. The terrain is hilly with parallel ridges and alternating narrow to wide valleys. The elevation ranges from 150 to 750 m above msl representing undulating land of gentle to very steep slops. The polyclonal population Hevea was raised from seeds obtained from specially maintained polyclonal seed garden. The polyclonal seedling clones were field planted in 1988-89 with seven clones planted in RBD with seven trees per plot and three replication with spacing of 6.60 m x 3.30 m. At the end of 10^{th} year, mean girth of the clones ranged from 63.9 to 78.2 cm and the clone SCATC 93-114 recorded maximum mean average girth of 78.2 cm followed by PB 235 (75.8 cm), GT 1 (74.4 cm), RRII 118 (71.9 cm), RRII 300 (71.5 cm), RRII 105 (66.7 cm) and minimum was in RRIM 600 (63.9 cm). The difference in girth was in the tune of 14.3 cm. A significant girth increment was also observed among the clones during the study period. The among the seven clones, SCATC 93-114 clone (62.9 cm) showed maximum mean girth increment followed by PB 235 (62.0 cm) and minimum was in RRIM 600 (45.5 cm) over a period of 10^{th} year. At the 7^{th} year, tappability percentage recorded. The maximum tappability percentage was recorded in SCATC 93-114 (72.5 %) followed by PB 235 (61.3 %), GT 1 (58.6 %), RRII 118 (54.5 %), RRII 300 (54.1 %), RRII 105 (23.7 %) and minimum was in RRIM 600 (14.3 %). The yield over 4^{th} year of regular tapping (1997-2000) revealed that SCATC 93-114 recorded the highest yield (36.9 g t^{-1} t^{-1}) followed by RRII 300 (36.0 g t^{-1} t^{-1}), PB 235 (35.4 g t^{-1} t^{-1}), GT 1 (32.8 g t^{-1} t^{-1}), RRII 118 (31.7 g t^{-1} t^{-1}), RRII 105 (30.2 g t^{-1} t^{-1}) and RRIM 600 (28.9 g t^{-1} t^{-1}). The soil texture was clay loam at the hill top and silty clay loam in the foot and mid hill. The increased clay content also in the foot hill could be due to deposition of clay particles in the foot hill by erosion from the hill top. Water holding capacity of the soils in the foot hill was comparatively higher. The soil were acidic in nature and the contents of organic carbon, CEC, available N, P ,K,Ca and Mg were also considerably higher in foot hill as compared to mid hill and hill top. The soil was classified as Typic Hapludults.*

Key Words*: Growth and growth parameters, Tappability, Yield and Projected yield, Hevea brasiliensis, Kolasib, Mizoram, North East India*

Introduction: Rubber (*Hevea brasiliensis*) trees can grow in a vast majority of the acid soils of the humid tropics. However, its performance and economic viability can be severely restricted where deep, very acid peat, rocky parent material is present and drainage is excessive or impeded. It thrives well in the laterites, lateritic and red soils of India formed under tropical wet-dry climate [1].

Mizoram is endowed with distinct physiographic units and the entire area is hilly. A Mizoram meaning is High Lander. In the climosequence ranging between per humid tropics and humid cool sub-temperate, varied types of soils have developed in Mizoram at different altitudes on similar types of parent materials. The acid soils of foot hills below 450 m above mean sea level (msl) developed under warm humid sub-tropical climate which run

north to south along the western belt of Mizoram are fairly suitable for growth and yield of rubber [2].

Rubber cultivation in the region was mostly confined to few public sector plantations till late 1970s. The crop, however, attracted public attention and the incentives offered by the Rubber Board contributed to the expansion of area in the small holding sector. The scheme for accelerated development of rubber plantations for the north eastern region since 1984-85 resulted in real expansion particularly in small holding sector. At present 1, 41,035 hectares area is under rubber cultivation and 55,280 tonnes production in the north- eastern region of India and 1,415 hectares area and 250 tonnes production covered under the Mizoram state [3]. (Table 1). In view of the limited scope for further expansion of area under rubber in traditional zone (8^0 15` N and $12^0$ 15` N latitude), cultivation of the crop was extended to less congenial but potential areas [4]. One of the regions selected was the Mizoram state of North-eastern India (22^0 N and 90^0 E). This is the first comprehensive report covering effect of slopes on the performance of seven different clones under the polyclonal seed garden in Mizoram condition.

Table 1. State wise area and production of natural rubber in North Eastern Region*

S.No.	State-wise area and production		
	States	Total Area (Hectares)	Production (Tonnes)
1.	Tripura	67,730	33,220
2.	Assam	43,335	11,740
3.	Meghalaya	12,865	7,110
4.	Mizoram	1,415	250
5.	Other Northeast states (Nagaland, Manipur, and Arunachal Pradesh)	15,690	2,960
	Total	1,41,035	55,280

**Source: Rubber and its cultivation. Rubber Grower`s Companion. p 88. (2015).*

Materials and Methods

This study was conducted at the Regional Research station of Rubber Research Institute of India at Tuichhuhen farm in Kolasib district of Mizoram. Mizoram in the north-eastern Himalayas lies between 22^0 00` and $24^0$15` N and $92^0$20` and $93^0$29` E. The terrain is hilly with parallel ridges and alternating narrow to wide valleys. The elevation ranges from 150 to 750 m above msl representing undulating land of gentle to very steep slops. The polyclonal population *Hevea* was raised from seeds obtained from specially maintained polyclonal seed garden. The polyclonal seedling clones were field planted in 1988-89 with seven clones planted in RBD with seven trees per plot and three replication with spacing of 6.60 m x 3.30 m.

The area has warm humid sub-tropical climate. It is influenced by the southwest monsoon from May to October and the north-east monsoon from November to April. The total annual rainfall ranges from 1932 to 3059 mm with a mean 2350 mm, recorded in almost all the months but the distribution in uneven. Total rainy days in a year averages 118. The relative humidity remains very high throughout the year varying from 64 to 95 per cent. In high hills, the monthly mean summer temperature ranges from 26.7 to 32.5^0C and 16.9 to 22.7^0C in winter whereas in low hills and valleys, the temperature fluctuates from 24.1 to 31.3^0 C during summer and 18.9 to 24.5^0 C in winter. The night temperature in valleys goes down to 5^0 C during winter (Table 2).

Table 2. Meteorological parameters of the study site during the period (1992-2000)

Months	Temperature (^{0}C)		Relative humidity (%)		Rainfall (mm)	Bright Sun Shine Hours	Wind Velocity (Kmh-1)	Evaporation (mm day^{-1})
	Tmax	Tmin	RHMax	RHMin				
January	27.3	11.13	89.7	71.3	13.0	5.9	1.6	1.7
February	29.8	12.30	91.3	65.0	24.1	6.2	2.2	2.1
March	32.5	14.70	91.0	64.0	164.9	7.1	3.2	2.4
April	34.3	20.03	90.7	66.7	200.1	6.7	2.7	2.7
May	33.5	21.80	91.7	75.3	408.4	3.7	3.6	2.7
June	34.0	22.97	95.0	78.7	328.5	3.0	3.3	1.8
July	33.9	23.33	91.7	77.7	327.5	3.5	2.5	1.2
August	33.5	23.33	92.0	76.7	400.6	2.4	1.9	3.0
September	33.9	23.03	91.3	75.7	292.9	4.0	1.8	1.7
October	33.0	22.47	91.0	80.7	164.9	4.8	1.9	2.0
November	31.6	18.00	92.0	75.3	24.4	6.3	1.8	2.6
December	28.8	12.53	90.0	72.3	0.3	7.1	2.4	2.4
Total/Mean	**32.2**	**18.80**	**91.4**	**73.3**	**2349.5**	**5.1**	**2.4**	**2.2**
SD	**2.5**	**4.87**	**1.8**	**7.6**	**168.5**	**1.9**	**0.7**	**0.7**

The plant girth was recorded twice in a year at the height of 150 cm from the bud union and yield was recorded monthly from may to January and February to April was given tapping rest during the stress period/winter. The tapping was started eight years after planting in 1997 under ½ Sd/26d/7 tapping system. Before and after 6 year of planting, composite surface soil samples (0-30 cm depth) were collected from the hillock separately (Representing foot hill, mid hill and hill top), air dried and passed through 2 mm sieve. The samples were analysed for particle size distribution by hydrometer method [5] and water holding capacity (WHC) following the method described [6]. Organic carbon, pH, Cation exchange capacity (CEC) and available Nitrogen (N), phosphorous (P), Potassium (K), calcium (Ca) and Magnesium (Mg) were also determined by following the standard methods. The initial soil was medium in organic carbon (9.2 g kg^{-1}), available P was very low (11.3 kg ha^{-1}), available K was medium (191.0 kg ha^{-1}) and available Mg was very high (322.8 kg ha^{-1}) and soil pH was strongly acidic in nature (Table 3).

Table 3. Pre-treatment soil analytical report of the site

Parameters	0-30 cm	30-60 cm	Mean of 0-60 cm
O.C. (g kg^{-1})	9.8	8.6	9.2
Available Phosphorus (kg ha^{-1})	12.5	10.1	11.3
Available Potassium (kg ha^{-1})	204.8	177.2	191.0
Available Magnesium (kg ha^{-1})	386.4	259.0	322.8
Soil pH(1:2.5)	4.91	4.76	4.84

The area has warm humid sub-tropical climate. This region experiences high temperature high rain fall. Daily minimum temperature was low in December, January and February and in the remaining months temperature was fairly high. Maximum temperatures exceed 32 ^{0}C during March to June. During summer, in the month of April and May the mean maximum temperature was recorded 34^{0}C. The monthly mean summer temperature ranges from 26.7 to 32.5^{0}C and 16.9 to 22.7^{0}C in winter whereas in low hills and valleys, the temperature fluctuates from 24.1 to 31.3^0 C during summer and 18.9 to 24.5^0 C in winter. The night temperature in valleys goes down to 5^0 C during winter. The relative humidity remains very high throughout the year varying from 64 to 95 per cent. In high hills the total annual rainfall ranges from 1932 to 3059 mm recorded in almost all the months but the distribution in uneven. The region received an annual rainfall 2350 mm during the study period and the rainy period around the year was 118 days. The distribution of satisfactory rainfall was seen in the region. The bright sun shine hours (BSSH) during June, July and August were low and moderate September and October. The BSSH was more than six hours daily in the remaining months. Evaporation was low in July and September and high during winter and summer period (Table 2).

Results and Discussion

Polyclonal Effect on Growth of Plants: Data pertaining to mean girth and annual girth increment of the clones during immature and mature phase of plantation (2nd to10th year) are presented in Table 4 and 5). At the end of 10th year , mean girth of the clones ranged from 63.9 to 78.2 cm and the clone SCATC 93-114 recorded maximum mean average girth of 78.2 cm followed by PB 235 (75.8 cm), GT 1 (74.4 cm), RRII 118 (71.9 cm), RRII 300 (71.5 cm), RRII 105 (66.7 cm) and minimum was in RRIM 600 (63.9 cm). The difference in girth was in the tune of 14.3 cm. A significant girth increment was also observed among the clones during the study period. The clone SCATC 93-114 registered a mean annual girth increment of 62.9 cm over a period of 10th year. The corresponding values for PB 235, GT 1, RRII 300, RRII 118, RRII 105 and RRIM 600 were 62.0, 59.2, 57.1, 54.1, 51.1 and 45.5 cm, respectively. At the commencement of tapping, number of trees attain tappability was highest in SCATC 93-114 (72.5 %) followed by PB 235 (61.3 %), GT 1 (58.6 %), RRII 118 (54.5 %), RRII 300 (54.1 %), RRII 105 (23.7 %) and minimum was in RRIM 600 (14.3 %) (Table 6).

Table 4: Annual mean girth recorded in cm from 1992 -2000

	Year-wise annual mean girth (cm)										Girth increment over 10 years
	1991									2000	
Clone		1992	1993	1994	1995	1996	1997	1998	1999		
RRII 105	13.13	16.50	24.43	30.43	36.97	44.07	51.17	53.57	58.84	66.70	**53.60**
RRIM 600	12.10	15.20	23.37	28.50	35.20	42.07	47.20	52.17	54.89	63.87	**51.80**
SCATC 93-114	14.03	19.13	29.17	36.93	45.07	52.80	61.00	63.60	70.26	78.2	**64.20**
RRII 300	14.03	18.37	27.30	33.93	41.03	48.00	56.07	61.67	63.30	71.47	**57.50**

RRII 118	14.17	18.70	28.87	36.37	43.83	50.67	56.63	60.00	64.12	71.87	**57.70**
GT 1	13.93	17.60	26.93	34.23	41.57	49.20	54.77	60.27	66.71	74.37	**60.40**
PB 235	13.57	17.40	26.83	34.77	41.77	50.20	57.17	61.33	68.43	75.83	**62.30**
Mean	**13.57**	**17.56**	**26.70**	**33.60**	**40.78**	**48.14**	**54.86**	**58.94**	**63.79**	**72.60**	**58.20**
SD	**0.74**	**1.36**	**2.14**	**3.07**	**3.54**	**3.81**	**4.47**	**4.33**	**5.42**	**4.96**	**4.48**

Table 5: Annual Girth Increment (AGI) (cm) from 1992 to 2000

	Year-wise annual mean girth increment (cm)										
Clone	1992	1993	1994	1995	1996	1997	1998	1999	2000	*AGI over 10 years	**AMGI (cm) over 10 years
RRII 105	3.37	7.93	5.97	6.57	7.10	7.10	2.40	5.34	5.34	**51.11**	**5.68**
RRIM 600	3.10	8.17	5.10	6.70	6.87	5.13	4.97	2.75	2.75	**45.53**	**5.06**
SCATC 93-114	5.10	10.03	7.67	8.17	7.77	8.20	2.63	6.65	6.65	**62.87**	**6.99**
RRII 300	4.33	8.93	6.63	7.13	6.97	8.10	5.60	4.69	4.69	**57.09**	**6.34**
RRII 118	4.53	10.17	6.90	8.07	6.87	5.93	3.40	4.11	4.11	**54.08**	**6.01**
GT 1	3.67	9.33	7.23	7.33	7.70	5.57	5.50	6.44	6.44	**59.21**	**6.58**
PB 235	3.83	9.43	8.03	6.90	8.43	6.97	4.13	7.13	7.13	**61.99**	**6.89**
Mean	**3.99**	**9.14**	**6.79**	**7.27**	**7.39**	**6.71**	**4.09**	**5.30**	**5.30**	**55.98**	**6.22**
SD	**0.70**	**0.86**	**1.01**	**0.63**	**0.60**	**1.21**	**1.32**	**1.57**	**1.57**	**6.21**	**1.05**

***AGI=** Annual Girth increment over 10 years; ****AMGI=** Mean Annual Girth Increment (cm) over 10 years

Table 6. Growth performance of popular clones under the polyclonal seed garden at sub-tropical climate

Clone	Mean girth (cm) at commencement of tapping (1996)	Tappability (%)	Mean Girth (cm) (1991)	Mean Girth (cm) (2000)	Girth increment over 10 years	AMGI* (cm)
RRII 105	44.5	23.7	13.1	66.7	53.6	**5.68**
RRIM 600	40.5	14.3	12.1	63.9	51.8	**5.06**
SCATC 93-114	53.8	72.5	14.0	78.2	64.2	**6.99**
RRII 300	48.3	54.1	14.0	71.5	57.5	**6.34**
RRII 118	50.5	54.5	14.2	71.9	57.7	**6.01**
GT 1	50.1	58.6	13.9	74.4	60.4	**6.58**
PB 235	9.9	61.3	13.6	75.8	62.3	**6.89**
Mean	**42.5**	**48.4**	**13.6**	**72.6**	**58.2**	**6.22**
SD	**15.0**	**21.2**	**0.74**	**4.96**	**4.48**	**1.05**

***AMGI=** Mean Annual Girth Increment (cm) over 10 years (1991 to 2000)

Polyclonal Effect on Yield: The yield over 4 years of regular tapping (1996 to 2000) revealed that SCATC 93-114 recorded the highest yield (36.9 g t^{-1} t^{-1}) followed by RRII 300 (36.0 g t^{-1} t^{-1}), PB 235 (35.4 g t^{-1} t^{-1}), GT 1 (32.8 g t^{-1} t^{-1}), RRII 118 (31.7 g t^{-1} t^{-1}), RRII 105 (30.2 g t^{-1} t^{-1}) and RRIM 600 (28.9 g t^{-1} t^{-1}) (Table 7). The projected yield (Kg ha^{-1} yr^{-1}) of the clones SCATC 93-114, RRII 300, PB 235, GT 1, RRII 118, RRII 105 and RRIM 600 were 1330, 1296, 1275, 1182, 1142,1090 and 1042, respectively (Table 8). Comparable yield of RRIM 600, RRII 105 and other clones has also been observed in other studies [7, 8, 9 & 10].

Table 7: Slope- wise mean yield (g t^{-1} t^{-1}) **under 1/2 S d/2 tapping system**

Clone	Foot Hill			Mean	Mid Hill			Mean	Hill Top			Mean yield
	1998	1999	2000	yield	1998	1999	2000	yield	1998	1999	2000	
RRII 105	28.9	27.1	38.2	**31.4**	28.1	31.9	36.8	**32.3**	22.5	24.2	34.5	**27.1**
RRIM 600	30.66	33.5	28.9	**31.0**	27.92	25.3	37.1	**30.1**	20.19	22.1	34.5	**25.6**
SCATC 93-114	38.29	35	49.9	**41.1**	37.13	38.1	42.3	**39.2**	23.72	24.2	43.3	**30.4**
RRII 300	32.00	37.10	47.50	**38.9**	29.11	39.10	42.00	**36.7**	28.68	25.70	42.40	**32.3**
RRII 118	30.82	33.2	38	**34.0**	31.81	33.5	38.9	**34.7**	23.28	21.3	34.2	**26.3**
GT 1	29.67	28.2	38.7	**32.2**	28.48	32.9	39.1	**33.5**	24.77	29.5	43.7	**32.7**
PB 235	32.7	44.6	39.7	**39.0**	29.73	28.2	42	**33.3**	18.75	36.8	45.8	**33.8**
Mean	**31.85**	**34.10**	**40.13**	**35.4**	**30.72**	**32.71**	**39.74**	**34.4**	**23.12**	**26.26**	**39.77**	**29.7**
SD	**3.12**	**5.85**	**6.91**	**5.3**	**3.28**	**4.94**	**2.36**	**3.5**	**3.22**	**5.36**	**5.13**	**4.6**

Table 8: Slope- wise Annual mean yield (g t^{-1} t^{-1}) **under 1/2 S d/2 tapping system**

Clone	**Foot hill**	**Mid hill**	**Hill Top**	**Mean***	**Projected yield (Kg/tree/year)**	**Projected yield** (Kg/ha/year)**
RRII 105	31.4	32.3	27.1	**30.2**	3.11	1090
RRIM 600	31.0	30.1	25.6	**28.9**	2.98	1042
SCATC 93-114	41.1	39.2	30.4	**36.9**	3.80	1330
RRII 300	38.9	36.7	32.3	**36.0**	3.70	1296
RRII 118	34.0	34.7	26.3	**31.7**	3.26	1142
GT 1	32.2	33.5	32.7	**32.8**	3.38	1182
PB 235	39.0	33.3	33.8	**35.4**	3.64	1275
Mean	**35.4**	**34.4**	**29.7**	**33.2**	**3.41**	**1194**
SD	**5.3**	**3.5**	**4.6**	**4.5**	**0.31**	**110**

**1997 to 2000 Mean yield (g t^{-1} t^{-1}); **Based on 350 trees per ha in 103 tapping days per year*

Polyclonal Effect on Soil: The physical and chemical properties of the soils are presented in Table 9. The soil texture was clay loam at the hill top and silty clay loam in the foot and mid hill.

The increased clay content also in the foot hill could be due to deposition of clay particles in the foot hill by erosion from the hill top. Water holding capacity of the soils in the foot hill was comparatively higher. The soil were acidic in nature and the contents of organic carbon, CEC, available N, P ,K,Ca and Mg were also considerably higher in foot hill as compared to mid hill and hill top. The soil was classified as Typic Hapludults [2].

Table 9. Slope-wise physical and chemical properties of soil after 6 years of planting (0-30 cm)

Soil parameters	Foot hill	Mid Hill	Hill Top
Soil Separates (%)			
Sand	18	20	24
Silt	42	41	39
Clay	40	39	37
Textural Class	Silty clay loam	Silty clay loam	Clay loam
Water Holding Capacity (%)	58	50	47
pH (1:2.5 w / v)	5.12	4.92	4.82
CEC (cmol (P+)/ kg)	11.5	9.6	7.2
Organic carbon (g kg^{-1})	15.6	14.3	13.6
Available Nitrogen (kg ha^{-1})	356	258	272
Available Phosphorus (kg ha^{-1})	13.5	9.6	7.8
Available Potassium (kg ha^{-1})	210	201	182
Available Calcium (kg ha^{-1})	237	224	209
Available Magnesium (kg ha^{-1})	306	277	269

Conclusion: This study showed that rubber can be grown successfully in Mizoram and that the performance the trees are better in the foot hills. Based on available data, clone SCATC 93/114 and PB 235 are more adapted for the location. The content of organic carbon, CEC, available N,P,K, Ca and Mg were also considerably higher in foot hill as compared to mid hill and hill top.

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