PERFORMANCE OF CLONES RRIM 2002 (PB 5/51 X FORD 351) AND PB 260 (PB 5/51 X PB 49) AT TWO DIFFERENT ELEVATIONS IN EAST MALAYSIA

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ABSTRACT

A task in rubber breeding programme, in subsequent stages, is to assess the performance of the available clones in various environmental conditions so that their adaptability and limitation can be ascertained for the future rubber clones development. The aim of this study was to compare the growth performance of two rubber clones i.e. RRIM 2002 and PB 260 under different elevations i.e. highland and lowland. This study was conducted at two different locations in Sabah, East Malaysia namely Pekan Nabalu, Kundasang and Hutan Simpan Ulu Tongod, Telupid. A total of 209 trees were sampled in Pekan Nabalu while for lowland cultivation area in Hutan Simpan Ulu Tongod, Telupid, 236 trees were sampled. This study indicates that the two rubber clones did not perform well in highland area. At the age of nine years after planting, the means for tree height, girth and bark thickness at 150 cm from the ground for clone PB 260 were 8.29 ± 1.59 m, 26 ± 7.19 cm and 3.40 ± 1.09 mm respectively. For clone RRIM 2002, the means were 7.90 ± 2.51 m, 24.36 ± 8.57 cm and 3.45 ± 1.01 mm, respectively. The poor performance of these clones in highland area in Pekan Nabalu, Kundasang was significantly affected by the unfavorable climate conditions which were ascribed to decreasing temperature as elevation increased. Such appraisals were used as an indication of the importance of new germplasm materials in the development of tolerant clones, or perhaps to some extent, resistant to low temperature clones.

Key words: *Hevea brasiliensis*, Highland Cultivation, Low Temperature, Elevation.

Introduction

Deforestation and land use change are responsible for large offsets of carbon to the atmosphere which is considered as a major contributor to the current climate variability and climate change (Anon, 2010). Global weather forecast indicated that the global mean temperature will increase by 1.5 ºC to 6.5 ºC (Brown et al., 1991), and the temperature has already increased by 0.3 ºC to 0.6 ºC in the last century (1900's). As the results, global warming is anticipated to result in some areas becoming drier while some other areas become wetter or cooler.

The rubber tree (*Hevea brasiliensis*) will best grow in a climate similar to its area of origin i.e. the Amazonas (Watson, 1989) where rainfall is heavy with no dry season (Köppen, 1923). Overall, the optimal climatic conditions for the genus *Hevea* are rainfall of 2000 mm or more which is evenly distributed throughout the year with no severe dry season and with 125-150 annual rainy days, maximum temperature of about 29-34°C with minimum of about 20°C and a monthly mean of 25-28°C, high atmospheric humidity of about 80% with moderate wind, and bright sunshine for about 2000 hours in a year at the rate of six hours a day in all months (Rao and Vijayakumar, 1992).

Compared to the traditional rubber areas, rubber cultivation in the highland is suspected not to perform well due to overall unfavorable climate conditions especially lower average annual temperatures at high elevations, lower and irregular rainfall, and lower atmospheric humidity during the dry season. Nevertheless, planting of rubber in high elevation areas is possible provided suitable planting material are used. Nowadays, in most Southern Asian countries including Malaysia, the competition for agricultural land by other crops and activities is one factor driving the establishment of rubber in new areas (Shamsuddin and Noordin, 2011).

The present study was carried out in order to evaluate the growth performance of two available rubber clones, namely RRIM 2002 and PB 260 with respect to different elevations in East Malaysia that is highland and lowland traditional rubber cultivation areas. Information about the growth performance and biomass accumulation of rubber clones cultivated in highland areas are crucial for future rubber forest plantation establishment and essential are for assessing the total and annual rubber timber vigor capacity (Mohd Aris, 2005). According to Malaysian Rubber Board, on 6.7 m x 3.6 m planting system, the girth measurement for RRIM 2002 and PB 260 at 7 year- old is expected to archive 54.0 cm and 56.3 cm on average, respectively.

As this study focused on the forestry-related uses of rubber, latex yields were not measured. However when assessing the general profitability of rubber, the latex yield component is currently the most significant factor in determining the viability of rubber cultivation. This paper compares the growth performance of clones RRIM 2002 and PB260 cultivated on the highland and lowland areas.

Research design

i. Description of the study site

For the highland, the study was performed in Kampung Balakan, Pekan Nabalu, Kundasang, Sabah. It is located about 75 km from Kota Kinabalu. The site is located at 06° 05' 126 N; 116° 26' 244 E; 1048 m a.s.l. Generally, the minimum and maximum mean temperature and humidity are 16.5ºC to 21.3ºC and 84% respectively from January 2012 until Jun 2013. The mean annual rainfall in 2012 was 2187.55 mm with 173 wet days and the dry season varied every year. The rubber was planted in 2004 at a planting distance of 1 m x 25 m (about 400 trees ha-1) and intercropped with pineapple. On average the land is sloping at 60 degree.

The lowland planting was at Hutan Simpan Ulu Tongod, Telupid, Sabah. It is located about 142 km from Sandakan at 05° 09' 48 N; 117° 02' 14 E; and 226 m a.s.l. Generally, the mean annual temperature and humidity are from 27.5ºC and 84.25% respectively. The mean annual rainfall in 2012 was 364.5 mm with 261 wet days and the dry season varied every year. The rubber clones were planted in 2004 through Sustainable Forest Management License Agreement (SFMLA) between Sabah Forestry Department and TSH Resources Berhad (Anon, 2011). The initial planting spacing was 4 m x 4 m and of the two plots each, there were about 98 and 90 planted trees on average for RRIM 2002 and PB 260, respectively.

ii. Data collection

In order to provide equal chance for each clone to be selected, the method of simple random sampling was applied for collecting field data in each location. Random numbers were computer generated based on the normal distribution before matched with the individual tree numbers as been identified earlier. For each clone, the number of trees sampled at each location was recorded.

The tree height (TH), the girth (G150) and bark thickness (BT) at 150 cm were measured to evaluate the tree growth performance while additional parameters such as clear bole height (CBH) and girth at small end were measured to estimate the clear bole volume (CBV) on each individual tree. The tree height in meter (m) unit was measured using laser ace hypsometer and the girth in centimeter (cm) unit was measured using measuring tape at 60 and 150 cm above ground respectively. The CBV or log volume was estimated by Truncated Cone formula.

$$CBV = \Pi/12\ ((D_1+D_2)^2 - D_1D_2)\ CBH$$ where;

D_1 is the large end diameter

D_2 is the small end diameter

For the comparison within the highland cultivation area and also between different elevation, independent sample t- test was employed to determine the significant different in growth performance and the estimated clear bole volume of these two clones. All the data were statistically analyzed at significant level (α) equal to 0.05 as to generalize the population at 95% confident level from which samples was drawn.

Results and discussion

For highland rubber cultivation area in Pekan Nabalu, Kundasang a total number of 209 trees were sampled. Out of these numbers, 107 trees were PB 260 clone and 102 trees were RRIM 2002 clone. The descriptive statistics on growth performance parameters such as the total height, the girth and bark thickness at 150 cm were shown in Table 1.

Table 1: Descriptive statistics on growth performance parameters in Pekan Nabalu, Kundasang

	PB 260 (*n= 107*)			RRIM 2002 (*n = 102*)		
Statistics	**TH**	**G150**	**BT**	**TH**	**G150**	**BT**
Mean	8.29	26.02	3.40	7.90	24.36	3.45
Standard Deviation	1.59	7.19	1.09	2.51	8.57	1.01
Minimum	3.19	10.4	1.00	2.16	11.60	2.00
Maximum	12.13	43.7	6.50	13.05	45.00	6.00
CV (%)	19.15	27.63	32.0	31.77	35.18	29.28

Note;
CV: Coefficient of Variation TH: Tree Height (m), G150: Girth at 150 cm from the ground, BT: Bark Thickness (mm)

From the results, the mean for the tree height, the girth and bark thickness at 150 cm for clone PB 260 was 8.29 ± 1.59 m, 26 ± 7.19 cm and 3.40 ± 1.09 mm while for clone RRIM 2002, the mean was 7.90 ± 2.51 m, 24.36 ± 8.57 cm and 3.45 ± 1.01 mm, respectively. In term of the variability within each parameter, for PB 260, the tree height was ranging from 3.19 m to 12.13 m with the variation of 19.15 %, the girth at 150 cm range from 10.4 cm to 43.7 cm with the variation of 27.63 % and the bark thickness was ranging from 1.00 mm to 6.50 mm with variation of 32.0 %. Compared with clone PB 260, clone RRIM 2002 showed higher dispersion since the variation for the tree height, the girth and bark thickness at 150 cm was 31.77%, 35.18% and 29.28%, respectively. Overall, clone PB 260 performed slightly better than clone RRIM 2002 since higher mean value in two of the parameters studied *i.e.* the tree height and the girth at 150 cm and also low variation in the bark thickness at 150 cm.

As for lowland area in Hutan Simpan Ulu Tongod, Telupid, a total number of 236 trees were sampled out of which 121 trees were clone PB 260 and 115 trees were clone RRIM 2002. The descriptive statistics on growth performance parameters such as the tree height, the girth and bark thickness at 150 cm on each clone were shown in Table 2.

Table 2: Descriptive statistics on growth performance parameters in Hutan Simpan Ulu Tongod, Telupid

	PB 260 *(n= 121)*			**RRIM 2002 (*n = 115*)**		
Statistics	**TH**	**G150**	**BT**	**TH**	**G150**	**BT**
Mean	14.76	62.10	7.00	13.97	70.75	8.57
Standard Deviation	2.24	13.01	1.25	2.69	13.96	1.71
Minimum	8.89	32.00	3.50	7.20	29.40	4.50
Maximum	18.29	89.20	10.50	18.91	100.00	13.00
CV (%)	15.20	20.95	17.83	19.28	19.74	19.95

Note;
CV: Coefficient of Variation TH: Tree Height (m), G150: Girth at 150 cm from the ground, BT: Bark Thickness (mm)

Descriptive statistics on growth performance parameters in lowland area i.e. Hutan Simpan Ulu Tongod, Telupid revealed that for PB 260, the mean for the tree height, the girth and bark thickness at 150 cm was 14.76 ± 2.24 m, 62.10 ± 13.01 cm and 7.00 ± 1.25 mm while for clone RRIM 2002, the mean was 13.97 ± 2.69 m, 70.75 ± 13.96 cm and 8.57 ± 1.71 mm, respectively. In addition to this, the value of variation coefficients were found to be less than or equal to 20 % in lowland area indicated that lower variability within the growth performance parameters as compared with highland cultivation area in Table 1.

Table 3: Growth performance means comparison within the highland cultivation area

	Pekan Nabalu, Kundasang				
Parameter	**PB 260**	**RRIM 2002**	***t***	**df**	
Tree Height (m)	8.29 (1.59)	7.90 (2.51)	1.36	169.46	ns
Girth at 150 cm (cm)	26.02 (7.19)	24.36 (8.57)	1.52	197.44	ns
Bark Thickness (mm)	3.42 (1.13)	3.45 (1.01)	-0.25	206.21	ns
Clear Bole Volume $_{60,150}$ (m^3)	0.023 (0.015)	0.016 (0.013)	3.74	207	****

Note: Standard Deviations appear in parenthesis below means. ns; not significant. *: $p < 0.05$, **: $p < 0.01$, ***: $p < 0.001$, **** : $p < 0.0001$

Results on clone i.e. PB 260 and RRIM 2002 growth performance mean comparison within highland cultivation area i.e. Pekan Nabalu, Kundasang were shown in Table 3. Additional parameter, the estimated clear bole volume was added in the analysis conducted. For clone PB 260 and RRIM 2002 comparison within highland cultivation area, the test was found to be statistically non- significant towards parameter i.e. the tree height, the girth and bark thickness at 150 cm since the t value was t(169.46) = 1.36, t(197.44) = 1.52 and t(206.21) = -0.25, respectively. However, only the estimated clear bole volume was found to be statistically significant, t(207) = 3.74 and ($p < 0.0001$). This indicate that the clone PB 260 (M = 0.023, SD = 0.015) have significantly higher estimated clear bole volume compare to clone RRIM 2002 (M = 0.016, SD = 0.013) in highland cultivation area.

Table 4: Growth performance means comparison between highland and lowland cultivation area

Parameter	**Pekan Nabalu, Kundasang**	**Hutan Simpan Ulu Tongod, Telupid**	***t***	**df**	
PB 260	***n = 107***	***n =121***			
Total Height (m)	8.29 (1.59)	14.76 (2.24)	-25.34	215.997	****
Girth at 150 cm (cm)	26.02 (7.19)	62.10 (13.01)	-26.29	191.415	****
Bark Thickness (mm)	3.40 (1.09)	7.00 (1.25)	-23.05	226	****

Clear Bole Volume (m^3)	0.023 (0.015)	0.241 (0.087)	-27.028	127.64	****
RRIM 2002	***n = 102***	***n= 115***			
Total Height (m)	7.90 (2.51)	13.97 (2.69)	-17.14	215	****
Girth at 150 cm (cm)	24.36 (8.57)	70.75 (13.96)	-29.85	192.20	****
Bark Thickness (mm)	3.45 (1.01)	8.57 (1.71)	-27.16	188.81	****
Clear Bole Volume (m^3)	0.016 (0.013)	0.207 (0.894)	-22.62	119.06	****

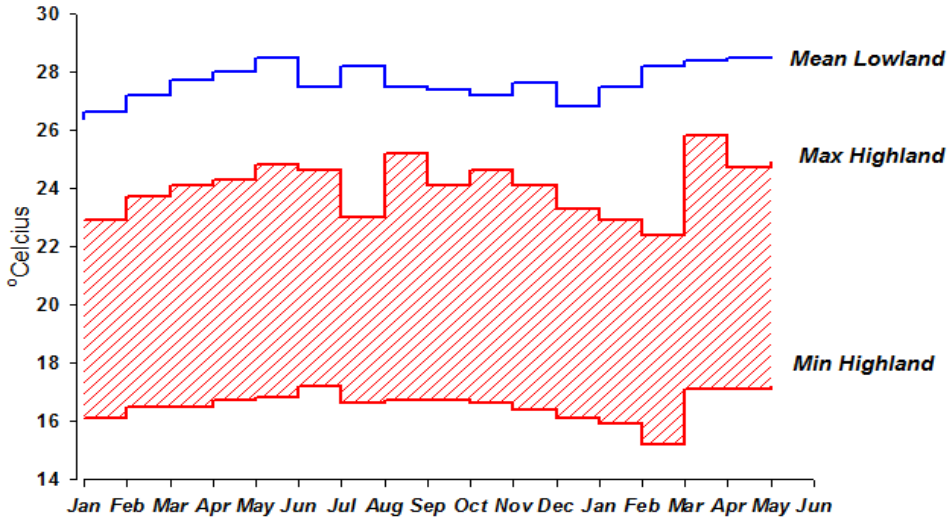
Note: Standard Deviations appear in parenthesis below means. ns; not significant. *: $p < 0.05$, **: $p < 0.01$, ***: $p < 0.001$, **** : $p < 0.0001$

The comparison of growth performance of clones between highland and lowland cultivation were shown in Table 4. Based on the result, all the tests on clone PB 260 and RRIM 2002 was found to statistically significant (p <0.0001) towards all the parameters involved in this study that were the tree height, the girth and bark thickness at 150 cm and the estimated clear bole volume. Thus, these concluded the poorer performance in term of the growth parameters under this study such as the tree height, the girth and bark thickness at 150 cm and the estimated clear bole volume of these two clones i.e.: PB 260 and RRIM 2002 at highland cultivation area as to compare with lowland cultivation area or likely known as traditional cultivation area.

Based on this study, it was found that the two rubber clones did not perform in highland cultivation area. The poorer performance of these two clones *i.e.* PB 260 and RRIM 2002 on higher elevation was ascribed to drop in temperature where by generally the drop in temperature being 0.5ºC for every rise of 100 m (Pushparajah, 1983). The following Figure 1 showed monthly temperature that was recorded from January 2012 until May 2013 in Kundasang and Hutan Simpan Ulu Tongod, Telupid. Based on this record, it was found that the monthly temperature for Kundasang from January 2012 to May 2013 was archived as low as 15.2ºC in February 2013 (Malaysian Meteorology Department).

As visible in Figure 1, lower temperatures have a tendency to restrict the development of rubber tree, such that even flowering and consequently fruiting are not possible at high elevations. On the other hand, at lower elevation, the temperature usually tends to be higher thus will increase the growing season. A longer growing season contributes to improve the metabolic activity of a plant, such that photosynthesis rate and cell growth can further increase (Song and Zhang, 2010). Therefore, the growth performance of rubber clones i.e. PB 260 and RRIM 2002 was significantly poorer at high elevation ranges might mainly cause by the reduction of temperature as the elevation increases.

Figure 1: Monthly temperature for Kundasang and Hutan Simpan Ulu Tongod,Telupid from January 2012 to May 2013



Source: Malaysian Meteorology Department

Although there are more potential species and clones for rubber plantation in Malaysia, the number is rather limited and it is important that the utilization of germplasm materials and more collection of wild *Hevea* species for South America to be introduce to augment the existing gene pool (Mohd. Aris, *et*. al.,2002). Hopefully, this finding therefore allows for the possibility that some of the present day, introduction of rubber clones too could be satisfactory at higher elevation ranges.

Due to several limitations in this study, it is suggested that physiological study towards the growth performance of the available rubber clones with respect to unfavorable climate condition and higher elevation should also to be conducted since it is insufficient to judge the plant performance based on limited number of growth parameters.

Conclusion

This study should be treated as indicative results for the evaluation of the available planting materials developed with narrow genetic base so that improved materials which are adaptable to cooler climate can be developed. In relation to rubber breeding programme, perhaps it would be appropriate for the plant breeders to consider developing cultivars which can perform in areas with slight environmental stress such as cooler climate condition. In view of this, it is important to increase the utilization of available germplasm materials based on experimental results, and to carry out collection of wild *Hevea* species from South America to augment the existing gene pool.

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