J. Rubb. Res., **17(4)**, 261–265

*Short Communication: Climate and Latex Production of Rubber Tree (*Hevea Brasiliensis *Muell. Arg.) in Wanning, Southeastern Part of Hainan Province, China*

H. ZHANG*#, L. ZHANG***, Y. GE****, Y. HUA**, Z. LAN** AND H. HUANG**

*Two clones of rubber tree (*Hevea brasiliensis *Muell. Arg.) were cultivated at experimental site of Xinzhong Filiale of Hainan Natural Rubber Group Company, Wanning City, Hainan Province, South China. The influences of five meteorological factors on latex yield were evaluated in seven years (2006-2012) by grey incidence, correlation and path analysis. The five meteorological factors were average temperature, rainfall, sunshine duration, relative humidity and ground temperature. Correlation and path coefficients were analysed between each of five climate factors and latex yield. There were significant correspondences between direct effects with latex yield for average temperature and ground temperature at –0.01 and 0.91 respectively. Grey incidence indicated that the correlation coefficient of latex yield with each of five meteorological factors varied from 0.22 (ground temperature) to 0.41 (relative humidity).*

Keywords: Rubber tree (*Hevea brasiliensis* Muell. Arg.); meteorological factors; latex yield; grey incidence; correlation and path analysis

Rubber tree (*Hevea brasiliensis* Muell. Arg) is native to the Amazonian rainforest and traditionally cultivated in the equatorial belts, tropical humid zones and monsoon climate[1,2]. Rubber tree is the only perennial crop being cultivated for commercial production of natural rubber in the world, though over 2,000 species of higher plants are recognised for producing latex[3]. Several countries are expanding cultivation of rubber tree to areas outside the scope of optimum climatic conditions for its high latex yield and excellent commercial properties of the natural rubber products. Attempts have been made to extend rubber

*School of Life Science, Huaibei Normal University / Anhui Key Laboratory of Plant Resources and Biology, Huaibei 235000, Anhui, China.
**Rubber Research Institute, Chinese Academy of Tropical Agricultural Sciences / Key Laboratory of Ministry of Agriculture for Tropical Crop Physiology, Danzhou, Hainan, 571737.
***Xinzhong Branch of Hainan Rubber Group, Wanning, Hainan, 571536.
****Haikou Experimental Station, Chinese Academy of Tropical Agricultural Sciences, Haikou, Hainan, 570102.
Corresponding author (e-mail: zhhuijun@126.com)

trees cultivation to areas as far north as 29 ºN in China and south as 23 ºS in Brazil which have widely different climatic constraints[4,5]. Meteorological factors such as temperature, rainfall, sunshine duration and typhoon still affect the yield of rubber[6–8].

Since the introduction of rubber in China, latex producers often face serious economic losses because rubber tree is vulnerable to suboptimal climate conditions in South China. Besides damage and low yield caused by low temperatures, each year the production of latex decreased or even stopped for a period of 3–5 months in southern China[9].

The present study measured the prevailing meteorological parameters which significantly influenced latex yield from April to December for seven years. The measuring record perhaps contributed towards an understanding of the correlation between each of five meteorological factors and latex yield by grey incidence, correlation and path analysis. A range of optimum environmental conditions were also identified for high latex yield.

EXPERIMENTAL

Materials and Methods

Two clones of *Hevea brasiliensis*, namely PR107 and PR600 were used in this experiment. The plants were grown following all standard agronomic practices in Xinzhong Filiale of Hainan Natural Rubber Group Company, Wanning City, Hainan Province, South China. Statistical data of latex yield and five meteorological factors, *viz*. average temperature, rainfall, sunshine duration, relative humidity, and ground temperature, were obtained at Wanning City in nine months (April to December) from 2006 to 2012. Mean monthly values of five meteorological factors and latex yield across the seven years are shown in *Table 1*. Grey incidence, correlation and path analysis were performed to evaluate the relationship between each of the meteorological factors and latex yield in DPS 7.05.

RESULTS

Significant positive and negative correlation coefficients were estimated between each of five meteorological factors and latex yield. Average temperature had significant positive correlation with ground temperature (0.91) (*Table 2*). In path analysis, there were positive direct effect between sunshine duration, relative humidity, ground temperature and latex yield. However, average temperature and rainfall had negative direct effects on latex yield (*Table 3*). Average temperature showed high negative direct effect (–2.70) while ground temperature exhibited maximum positive direct effect (2.94). The correlation coefficient of grey incidence between latex yield and each of five meteorological parameters varied from 0.22 (rainfall) to 0.41 (average temperature). The correlation degree of the five components to latex yield in decreasing order were average temperature (0.413) > ground temperature (0.410) > relative humidity (0.401) > sunshine duration (0.371) > rainfall (0.222).

DISCUSSION

Climatic conditions were critical factors in cultivation of rubber tree in nontraditional zones, temperature, sunshine, humidity, and rainfall in the nontraditional agroclimatic zones influenced latex yield[10,11]. Temperature is an important factor affecting photosynthesis, higher temperature leading to respiratory rates, resulting in a weakened photosynthetic capacity in the leaves[11]. The path analysis for latex yield indicated that the negative correlation was remarkably manifested by

TABLE 1. MEAN MONTHLY VALUES OF FIVE METEOROLOGICAL FACTORS AND LATEX YIELD OF *H. BRASILIENSIS* ACROSS THE SEVEN YEARS

Years	Average temperature (ºC)	Rainfall (cm)	Sunshine duration (h)	Relative humidity (%)	Ground temperature (ºC)	Latex yield (kg/667 m^2)
2006	26.9	19.3	181.6	79.3	31.4	45.1
2007	26.5	19.4	166.8	81.9	30.5	26.2
2008	26.5	19.4	166.8	81.9	30.5	42.0
2009	26.3	25.9	165.2	81.5	30.2	38.1
2010	26.0	13.8	178.3	79.9	28.78	36.6
2011	26.0	14.3	182.9	79.4	28.6	40.6
2012	26.5	18.7	190.1	82.7	29.5	40.2

TABLE 2. CORRELATION COEFFICIENTS OF FIVE METEOROLOGICAL FACTORS AND LATEX YIELD OF *H. BRASILIENSIS*

Meteorological factors	Average temperature (ºC)	Rainfall (cm)	Sunshine duration (h)	Relative humidity (%)	Ground temperature (ºC)	Latex yield
Average temperature (ºC)	1.00	0.45	-0.01	0.20	0.91**	0.22
Rainfall (mm)	0.45	1.00	-0.55	0.49	0.62	-0.04
Sunshine duration (h)	-0.01	-0.55	1.00	-0.26	-0.39	0.44
Relative humidity (%)	0.20	0.49	-0.26	1.00	0.16	-0.35
Ground temperature (ºC)	0.91**	0.62	-0.39	0.16	1.00	0.08
Latex yield	0.22	-0.04	0.44	-0.35	0.08	1.00

**: Significant at $p \leq 0.01$
**$P < 0.01$

TABLE 3. DIRECT AND INDIRECT EFFECTS OF FIVE METEOROLOGICAL FACTORS ON LATEX YIELD OF *H. BRASILIENSIS*

Meteorological factors	Direct effects	Indirect effects				
		Average temperature (ºC)	Rainfall (cm)	Sunshine duration (h)	Relative humidity (%)	Ground temperature (ºC)
Average temperature (ºC)	-2.70		-0.04	-0.03	0.24	2.68
Rainfall (mm)	-0.09	-1.21		-1.11	0.59	1.82
Sunshine duration (h)	2.02	0.03	0.05		-0.32	-1.14
Relative humidity (%)	1.21	-0.54	-0.05	-0.53		0.46
Ground temperature (ºC)	2.94	-2.47	-0.06	-0.79	0.19	

direct effect of average temperature on latex yield. The negative correlation and direct effect suggested that the higher the average temperature, the lower the latex yield. Similarly, Omokhafe and Emuedo[12] also found that maximum temperature had strong negative direct effect on latex yield. Previous studies in South China, indicated that the temperature range of 18–24ºC was conducive to latex flow[13] while the average temperature in the present study, ranging from 26ºC (2010 and 2012) to 26.9ºC (2006) exceeded by 2-3ºC from the favourable temperature range of 18–24ºC, could bring about failure in latex flow. In addition, the path analysis for latex yield demonstrated that ground temperature had high positive direct effect on latex yield. Raj[11] also suggested that soil and air temperature fluctuations prominently affected the daily yield of rubber in northeast India. Based on these results, air and ground temperatures appeared to be the significant criteria for improvement of latex yield in suboptimal environments.

In this study, the grey incidence analysis indicated that relative humidity had higher correlation with latex yield. The path analysis also showed that relative humidity exhibited positive direct effect on latex yield, suggesting that relative humidity should be considered as a critical factor for latex yield when selecting sites in nontraditional zones[12]. Higher humid zones of South China such as Hainan Province could contribute to the growth of rubber tree and also enhance latex producing ability of the rubber tree.

CONCLUSION

The correlation analysis showed that there were significant correspondences between direct effects with latex yield for average temperature and ground temperature at -0.01 and 0.91, respectively. The path analysis for latex yield demonstrated that average temperature had remarkably negative direct effect on latex yield, while ground temperature had high positive direct effect on latex yield. The grey incidence analysis indicated that the correlation degree of the five components to latex yield in decreasing order were average temperature (0.413) > ground temperature (0.410) > relative humidity (0.401) > sunshine duration (0.371) > rainfall (0.222).

Date of receipt: April 2014
Date of acceptance: October 2014

REFERENCES

1. ONOKPISE, O.U. (2004) Natural Rubber, *Hevea brasiliensis* (Willd. Ex A. Juss.) Muell. Arg., Germplasm Collection in the Amazon Basin, Brazil: A Retrospective. *Econ. Bot*., **58**, 544–555.

2. SOUZA, L.M., MANTELLO, C.C., SANTOS, M.O., DE SOUZA GONCALVES, P. AND SOUZA, A.P. (2009) Microsatellites from Rubber Tree (*Hevea brasiliensis*) for Genetic Diversity Analysis and Cross-amplification in Six *Hevea* Wild Species. *Conserv. Genet. Resour*., **1**, 75–79.

3. VENKATACHALAM, P., THULASEEDHARAN, A. AND RAGHOTHAMA, K. (2007) Identification of Expression Profiles of Tapping Panel Dryness (TPD) Associated Genes from the Latex of Rubber Tree (*Hevea brasiliensis* Muell. Arg.). *Planta*, **226**, 499–515.

4. PUSHPARAJAH, E. (1983). Problems and Potentials for Establishing *Hevea* Under Difficult Environmental Conditions. Thai IRRDB-Symposium. *Plant* **59**, 242–251.

5. SETHURAJ, M.R., POTTY, S.N., VIJAYAKUMAR, K.R., KRISHNAKUMAR, A.K., RAO, P.S., THAPALIYAL, A.P., MOHANKRISHNA, T.P., RAO, G.G.,

CHOUDHURY, D., GEORGE, M.J., SOMAN, T.A. AND MEENATOOR, J.R. (1989) Growth Performance of *Hevea* in the Nontraditional Regions of India. *Proceedings of the Rubber Research Institute of Malaysia, Rubber Grower's Conference, August 1989, Malacca, Malaysia*. Kuala Lumpur: RRIM, 212–227.

6. RAO, G.G., RAO, P.S., RAJAGOPAL, R., DEVAKUMAR, A.S., VIJAYAKUMAR, K.R. AND SETHURAJ, M.R. (1990). Influence of Soil Meteorological Factors on Water Relations and Yield in *Hevea brasiliensis*. *Int. J. Biometeorol*., **34**, 175–180.

7. PRIYADARSHAN, P.M. AND DE GONCALVES, S.P. (2003) *Hevea* Gene Pool for Breeding. *Genet. Resour. Crop Evol*., 50, 101–114.

8. KOSITSUP, B., MONTPIED, P., KASEMSAP, P., THALER, P., AMEGLIO, T. AND DREYER, E. (2009) Photosynthetic Capacity and Temperature Responses of Photosynthesis of Rubber Trees (*Hevea brasiliensis* Mull. Arg.) Acclimate to Changes in Ambient Temperatures. *Trees*, **23**, 357–365.

9. JIANG, A.L. (1988) Climate and Natural Production of Rubber (*Hevea brasiliensis*) in Xishuangbanna, Southern Part of Yunnan Province, China. *Int. J. Biometeorol*, **32**, 280−282.

10. RAY, D., DEY, S.K. AND DAS, G. (2004) Significance of the Leaf Area Ratio in *Hevea brasiliensis* under High Irradiance and Low Temperature Stress. *Photosynthetica*, **42**, 93−97.

11. RAJ, S., DAS, G., POTHEN, J. AND DEY, S.K. (2005). Relationship Between Latex Yield of *Hevea brasiliensis* and Antecedent Environmental Parameters. *Int. J. Biometeorol*, **49**, 189–196.

12. OMOKHAFE, K.O. AND EMUEDO, O. (2006) Evaluation of Influence of Five Weather Characters on Latex Yield in *Hevea brasiliensis*. *Int. J. Agric. Res*., **3**, 234−239.

13. SHUOCHANG, A. AND YAGANG, G. (1990) Exploration of the High Yield Physiological Regulation of *Hevea brasiliensis*. In: Proceedings of the IRRDB Symposium on Physiology and Exploitation of *Hevea brasiliensis*. IRRDB, Kunming, China, 83–92.