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Evaluation of Influence of Five Weather Characters on Latex Yield in *Hevea brasiliensis**

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Abstract: Ten clones of *Hevea brasiliensis* Muell. Arg. were evaluated at experimental site of Rubber Research Institute of Nigeria at Calabar, Nigeria for latex yield and influence of five weather factors in three years (1991-1993). The experimental design of the clonal field was randomized complete block with four replications. The clonal field was exploited for latex at ½ S, $d/_2$ tapping frequency while data on five weather factors in the trial site were obtained from the Federal Department of Meteorological Services, Lagos, Nigeria. The weather factors were minimum and maximum temperature, relative humidity (rh) at 0900 h GMT and 1500 h GMT and rainfall. Analysis of variance of clonal latex yield and each weather factor was conducted. Intercharacter correlation and path coefficients were calculated between pairs of characters within the six characters consisting of latex yield and five weather factors. There was significant variation for clonal latex yield and the weather factors. There was correspondence between direct effect and correlation coefficient with latex yield for maximum temperature at -1.90 and -0.39, respectively. Similar trend was obtained for rh (0900 h GMT) at direct effect and correlation coefficient of 0.800 and 0.422, respectively.

Key words: *Hevea*, latex, weather factors, correlation, path analysis

Introduction

The rubber tree (*Hevea brasiliensis*) is cultivated worldwide in the humid tropics with optimum weather conditions of ±28°C mean annual temperature, relative humidity of 67-82.3%, rainfall of 1400-4000 mm distributed over 100-182 days (Priyadarshan, 2003a). Several rubber producing countries are expanding cultivation of rubber to areas outside the scope of optimum weather conditions in order to meet increasing demand for natural rubber, capture otherwise 'waste' land, enhance economic activities of rural dwellers and boost of export trade to earn foreign exchange. In addition, *H. brasiliensis* is cultivated in non-traditional areas as escape zone for some devastating diseases such as the South American Leaf Blight in Brazil (Priyadarshan and Clement-Demange, 2004).

Priyadarshan (2003b) and Das *et al*. (2005) noted that weather condition is a critical factor in cultivation of rubber in non-traditional zones. Omokhafe and Alika (2003) reported that path analysis enhances the use of linear correlation and these statistical tools are therefore relevant in the understanding and application of the relationship between weather factors and latex yield. The objective of the study was therefore to evaluate the influence of five weather factors on latex yield in *Hevea brasiliensis* using correlation and path analysis.

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Materials and Methods

Ten clones of *Hevea brasiliensis* Muell. Arg. were planted in 1982 at Calabar (5°N, 8.5°E) in Cross River State, Nigeria. The clones were NIG 800-NIG 805 and C I59, developed by Rubber Research Institute of Nigeria and three exotic clones viz., RRIC 45, RRIM 600 and IAN 710 from Sri Lanka, Malaysia and Brazil, respectively. The experimental design was the randomized complete block with four replications. Latex yield was evaluated in three periods of the year for three years from 1991 to 1993. The periods were January to May, June to September and October to December as recommended by Omokhafe and Alika (2003). Tapping frequency was ½ S, $d/_2$ and latex yield was recorded as gam per tree per tapping (g/t/t) as described by Omokhafe and Nasiru (2004). There was no yield stimulation.

Data on five weather parameters at Calabar from 1991 to 1993 were obtained from the Federal Department of Meteorological Services, Lagos, Nigeria. The weather factors were minimum and maximum temperature, relative humidity at 0900 and 1500 h Greenwich Mean Time (GMT) and rainfall.

Factorial analysis of latex yield was carried out with clones, year and period, and their interactions as sources of variation. Two-way analysis of variance was applied to evaluate variation due to each of the weather factors. Intercharacter correlation was taken across six entries consisting of the three periods and three years. Correlation and path analysis were used to estimate the relationship between each of the weather factors and latex yield.

Results

There was significant variation in latex yield across the three years, three periods of the year and the ten clones. The effects of interactions were significant for year x period and clone x year (Table 1). Latex yield obtained in each of NIG 800, NIG 803, NIG 804, RRIC 45, RRIM 600 and C 159 was higher than the overall mean (Table 2). The period from October to December had the highest latex yield, while the highest annual latex yield was obtained in 1991 (Table 3 and 4).

Variation due to each of temperature (minimum and maximum), rainfall and relative humidity (rh) at 1500 h GMT was significant across the three periods while only minimum temperature was significant across the three years of evaluation (Table 5). The mean maximum temperature for October to December was a reliable estimate of the overall mean (Table 3). Relative humidity at 1500 h GMT and rainfall recorded the highest figures in June to September (Table 3). Across the three years, the highest level of mean minimum temperature was in 1991 (Table 4).

Table 1: Analysis of variance of latex yield in *H. brasiliensis*

SV	df	Sum of squares	Mean squares
Replicate	3	721.54	240.513*
Year (Yr)	2	11923.226	5961.613**
Period (P)	2	3478.65	1739.325**
Clone (Cl)	9	4495.912	499.546**
Yr×P	4	1049.272	262.318*
Cl×Yr	18	2313.787	128.544*
Cl×P	18	724.746	40.264
Cl×Yr×P	36	850.888	23.358
Error	267	19064.852	71.404

*, **: Significant at $p \leq 0.05$ and $p \leq 0.01$, respectively (F-test)

Table 2: Clonal means of latex yield in ten clones of *H. brasiliensis*

Clone	Latex yield (g/t/t)*, +
NIG 800	24.34 (6)
NIG 801	21.90 (8)
NIG 802	20.32 (9)
NIG 803	24.80 (5)
NIG 804	29.20 (1)
NIG 805	22.52 (7)
C 159	24.99 (4)
RRIM 600	25.27 (3)
IAN 710	16.64 (10)
RRIC 45	28.52 (2)
Overall mean	23.85

+: Figures in parenthesis represent rank, *: g/t/t = Gram per tree per tapping

Table 3: Mean monthly values of four significant weather factors and latex yield of *H. brasiliensis* across the three periods of the year

	Weather factors				
	Temperature (°C)				
Period	Maximum	Minimum	Rh (%) 1500 h (GMT+)	Rainfall (mm)	Latex yield (g/t/t)
Jan.-May	32.04	23.80	62.10	141.00	19.46
June-Sept.	28.43	23.00	81.25	397.62	25.83
Oct.-Dec.	30.39	22.92	68.00	140.59	26.26
Overall mean	30.29	23.24	70.45	226.40	23.85

Rh: Relative humidity, +: GMT = Greenwich Mean Time

Table 4: Mean monthly values of significant weather factor (minimum temperature) and latex yield of *H. brasiliensis* across the three years of evaluation

Year	Minimum temperature (°C)	Latex yield (g/t/t)*
1991	23.60	31.96
1992	22.87	20.36
1993	23.25	19.23
Overall mean	23.24	23.85

*: g/t/t = Gram per tree per tapping

Table 5: Mean squares of analysis of variance of maximum (X_1) and minimum (X_2) temperature, rainfall (X_3), and relative humidity at 0900 h (X_4) and 1500 h (X_5) GMT+

		Mean squares				
S.V.	df	(X_1)	(X_2)	(X_3)	(X_4)	(X_5)
Period	2	9.816 **	0.708**	65958.349**	72.720	288.548**
Year	2	0.019	0.393*	867.63	0.300	5.368
Error	4	0.259	0.440	834.69	38.847	10.039

*, **: Significant at $p \leq 0.05$ and $p \leq 0.001$, respectively (F-test), +: GMT = Greenwich Mean Time

Table 6: Correlation coefficients of latex yield of *H. brasiliensis* and five weather characters

		Weather characters			
		Temperature (°C)		Relative humidity (Rh)	
Weather characters	Latex yield	Minimum	Maximum	0900 h GMT+	1500 h GMT+
Temp. (Minimum)	0.047				
Temp. (Maximum)	-0.390	0.647			
Rh 0900GMT+	0.422	-0.593	-0.995**		
Rh 1500GMT+	0.424	-0.457	-0.973**	0.983**	
Rainfall	0.300	-0.310	-0.885*	0.885*	0.945**

*, **: Significant at $p \leq 0.05$ and $p \leq 0.001$, respectively (t-test), +: GMT = Greenwich Mean Time

Table 7: Direct (diagonal) and indirect (off-diagonal) effects of five weather characters on latex yield of *H. brasiliensis*

	Weather characters					
	Temperature (°C)		Relative humidity (Rh)			
Weather characters	Minimum	Maximum	0900 h GMT+	1500 h GMT+	Rainfall	Latex yield
Temp. (Minimum)	1.159	-1.229	-0.474	0.159	0.432	0.047
Temp. (Maximum)	0.750	-1.900	-0.800	0.330	1.230	-0.390
Rh 0900 h GMT+	-0.689	1.890	0.800	-0.344	-1.235	0.422
Rh 1500 h GMT+	-0.530	1.849	0.786	-0.361	-1.320	0.424
Rainfall	-0.360	1.682	0.708	-0.330	-1.400	0.300
Residual effect						0.666

+: GMT = Greenwich Mean Time

Significant and negative correlation coefficients were obtained between three pairs of characters viz., maximum temperature with each of rh (0900 and 1500 h GMT) and rainfall (Table 6). Positive and significant correlation coefficients were obtained between rh (1500 h GMT) with each of rh (0900 h GMT) and rainfall, and rh (0900 h GMT) with rainfall (Table 6). In path analysis, there was great correspondence between the direction of direct effect and correlation with latex yield for each of minimum and maximum temperature and rh (0900 h GMT) while there was reversed direction of between direct effect and correlation for rh (1500 h GMT) and rainfall (Table 7).

Discussion

Significant clonal variation for clones, year and period of evaluation is in agreement with the report of Omokhafe (2004). The outstanding performance of NIG 803 and NIG 804 for latex yield is in agreement with the report of Omokhafe and Alika (2003). The highest latex yield from October to December is similar to the annual trend of latex production in India and Southern Brazil. Weather factors and phenology were implicated for the yield depression from January to September and high yield from October to December (Omokhafe, 2004; Priyadarshan and Clement-Demange, 2004). The highest level of minimum temperature obtained in 1991 was closely associated with the highest annual mean latex yield. The positive direct effect of minimum temperature greater then unity, implies that the higher the minimum temperature, the higher the level of latex yield. In this study, this trend was well demonstrated by the highest level of latex yield and minimum temperature in 1991.

The significant interaction between clone and each of period and year suggests the variable response of clones to environmental conditions. Clonal stability tests will be conducted in further studies. Another implication of the clone×environment interaction is the effect of changing environmental conditions of latex yield. In addition to genetic factors responsible for clonal variation, the combination of significant interactions and effect of weather factors, as component of the environment also account partly for the significant clonal variation. Since the effect of external factors such as weather parameters are significant in this study, intercharacter correlation and path analysis enhanced the understanding of the effect of weather factors on latex production.

Path analysis is a useful tool to decompose correlation coefficient into direct and indirect effects (Omokhafe, 2001). This is important since, in nature, two correlated characters will have the influence of other characters. The cumulative effect of main (direct) effects and influence of other characters (indirect effects) produced the observed correlation coefficient. The practical use of correlation coefficient is therefore enhanced by path analysis.

The negative correlation between maximum temperature and latex yield is in agreement with the report of Sailajadevi *et al*. (1998). The negative correlation was strongly manifested by direct effect of maximum temperature on latex yield. The correspondence between correlation and direct effect makes the effect of maximum temperature on latex yield a very reliable character. The negative correlation and direct effect suggest that the higher the maximum temperature, the lower the latex yield. This is expected as higher temperatures result in high evapotranspiration and respiratory rates which could reduce net accumulation of photosynthates. The range of optimum maximum temperatures will be determined through regression equations in further studies.

For relative humidity (rh) at 0900 h GMT, the consistent relationship with positive direct effect and correlation means the higher the rh (0900 h GMT), the higher the latex yield. The consistent relationship between direct effect and correlation coefficient for maximum temperature and rh at 0900 h GMT suggests that combination of maximum temperature and rh at 0900 h GMT are critical factors when selecting sites in non-traditional zones.

The positive correlation between rainfall and latex yield is though supported by reports of Rao *et al*. (1998) and Sailajadevi *et al*. (1998), the negative direct effect of rainfall means that the application of the correlation between rainfall and latex yield will produce inconsistent field results. Similarly, the positive correlation between rh at 1500 h GMT though supported Sailajadevi *et al*. (1998), the negative direct effect will limit the application of the positive correlation coefficient.

The direct effect of minimum temperature greater than unity is encouraging but the very low and insignificant correlation limits the application of the direct effect. Since measurements are normally taken on phenotype, a very low phenotypic correlation irrespective of an apparently reliable direct effect will be of low practical relevance. The relatively high residual effect could be reduced in further studies by including more weather factors. Latex parameters such as initial flow rate and plugging index as recommended by Dey *et al*. (1999) could also be included.

In conclusion, there was significant clonal variation of latex yield with one of the Nigerian clones (NIG 804) as the best latex yielding clone. In the choice of expansion sites for cultivation of the rubber tree in non-traditional zones, maximum temperature and relative humidity at 0900 h GMT are critical factors in order to ensure optimum latex yield of the rubber trees. The physiological bases of such response will be investigated in further studies.

References

Das, G., R. Singh, G.C. Satisha and D. Chaudhuri, 2005. Performance of rubber clones in dooars area of west Bengal. International Natural Rubber Conference, Cochin, India, pp: 103-107.

Dey, S.K., K.R. Vijayakumar, D.B. Nair and P. Subramanian, 1999. Effect of temperature and vapor pressure on major yield components of rubber in humid and dry sub-humid climatic regious. Ind. J. Natural Rubber Res., 12: 69-76.

Omokhafe, K.O., 2001. Preliminary investigation into tree dryness in *Hevea brasiliensis* by path analysis of tree dryness and latex parameters. Tropicultura, 19: 1-4.

Omokhafe, K.O. and J.E. Alika, 2003. Clonal stability of latex yield in eleven clones of *Hevea brasiliensis*. Gen. Mol. Biol., 26: 313-317.

Omokhafe, K.O. and J.E. Alika, 2003. Correlation and path coefficients of seed and juvenile characters with respect to latex yield in *Hevea brasiliensis* Muell. Arg. Tropicultura, 21: 173-178.

Omokhafe, K.O., 2004. Interaction between flowering pattern and latex yield in *Hevea brasiliensis* Muell. Arg. Crop Breed. Applied Biotech., 4: 280-284.

Omokhafe, K.O. and I. Nasiru, 2004. Polygene inheritance of latex yield in *Hevea brasiliensis* Muell. Arg. Plant Gen. Resour. Newslett., 139: 60-62.

Priyadarshan, P.M., 2003a. Breeding *Hevea brasiliensis* for environmental constraints. Adv. Agron., 79: 351-400.

Priyadarshan, P.M., 2003b. Contributions of weather variables for specific adaptation of rubber tree (*Hevea brasiliensis* Muell. Arg.) clones. Gen. Mol. Biol., 26: 435-440.

Priyadarshan, P.M. and A. Clement-Demange, 2004. Breeding *Hevea* rubber: Formal and molecular genetics. Advances in Genetics, 52: 51-115.

Rao, P.S., C.K. Saraswathyamma and M.R. Sethuraj, 1998. Studies on the relationship between yield and meteorological parameters of para rubber tree (*Hevea brasiliensis*). Agric. For. Meteorol., 90: 235-245.

Sailajadevi, T., R.B. Nair, R. Kothandaraman and M.R. Sethuraj, 1996. Impact of Weather Parameters on Seasonal and Inter-year Variations in Yield of Rubber, In: Mathew, N.M., C.K. Jacob, (Eds.). Developments in Plantation Crops Research. Allied Publishers Ltd., New Delhi, India, pp: 170-174.