J. nat. Rubb. Res., **4(1)**, 66–74

Effects of Selected Environmental and Technological Factors on Rubber Production — A Case Study of RRIM Economic Laboratory

MOHD. NAPI DAUD*, JAMES NAYAGAM* AND P. VERAMUTHOO*

Production of rubber in a certain locality is dependent on a number of biological, environmental and technological factors. In this paper, the effects of selected environmental and technological factors such as rainfall, tapping days, wintering, improved tapping technique and yield stimulation on production in the RRIM Economic Laboratory at Kota Tinggi, Johore Darul Takzim were studied. The data covered a twelve-year period.

The analyses were done in two stages. In the first stage, the effects of diurnal and monthly variations of rainfall on output were assessed; whereas in the second stage, the Cobb-Douglas production model was used to measure the combined effects of environmental and technological factors on production.

The findings showed that the wettest months were October to January which were also the highest yielding months and, thus, losses in potential crop due to rain interference in these months were substantial. The regression analysis showed that all variables used in the model except stimulation dummy were significant at $P < 0.05$. These variables explained approximately 62% of the total variation in the prodction of rubber in the RRIM Economic Laboratory.

The amount of rubber output obtained from given high-yielding cultivars in a locality is dependent on a number of environmental and technological factors. Of the environmental factors weather conditions, particularly the time and amount of rainfall, have adverse effects on output. Occurrence of rainfall during the normal working hours when tapping is carried out usually disrupts or prevents the harvesting of latex, thus affecting the quantity and quality of latex collected[1]. A higher number of rainy days during a period decreases yield, and rainfall intensity beyond 10–11 mm rain per rainy day is not congenial to high yields[2]. On the other hand, improved techniques of tapping and the periodical application of yield stimulants increase the output of rubber significantly, thus improving the economic returns from rubber cultivation[3,4].

This paper assesses the effects of selected environmental and technological factors on rubber production in the RRIM Economic Laboratory. The environmental factors considered are rainfall, tapping days and wintering while the technological factors are improved tapping technique (controlled upward tapping) and yield stimulation.

The RRIM Economic Laboratory in Kota Tinggi, Johore Darul Takzim covers an area of approximately 133 ha. Of this area, only 103 ha are under mature rubber — 60% RRIM 600 clones and 40% RRIM 623 and RRIM 701 clones. This area of 103 ha is being used to test the Incentive Wage Concept which was formulated by the RRIM as an alternative approach to developing agricultural land in the country. Under this concept, the settlers or participants receive monthly wages based on an incentive system and, also, they share in the profit on the basis of individual productivity. Eighteen participants (husband-wife teams) tap the trees and maintain the 103 ha (approximately 5.7 ha per husband-wife team). This project has been in operation since 1976[5].

*Rubber Research Institute of Malaysia, P.O. Box 10150, 50908 Kuala Lumpur, Malaysia

DATA AND ANALYTICAL METHODS

The monthly rainfall, production and tapping days data used for analyses cover a twelve-year period 1976–87. Since the monthly rainfall record for August 1978 was not available, an estimated value was used to fill the missing cell when analyses were carried out. Stimulation data cover only the period 1984–7. This is because stimulation was introduced on *Panel BO-2* in 1984 and subsequently in mid-1986 on the upward cut when the controlled upward tapping (CUT) system was adopted.

Data analyses were carried out in two stages. In the first stage, the effect of diurnal (daily) and monthly variations of rainfall on output (yield) was assessed and in the second stage, the combined effects of rainfall, tapping days, wintering, stimulation and CUT on production were measured. For this measurement, the regression analysis based on the Cobb-Douglas model was used[6].

The general equation of the Cobb-Douglas model is as follows:

$$Y = KX_1\alpha_1 \, . \, X_2\alpha_2 \, . \, X_3\alpha_3 \ldots X_n\alpha_n \qquad \ldots 1$$

The logarithmic transformation of *Equation 1* gives the following linear model:

$$\ell\text{n}\, Y = \ell\text{n}\, k + \alpha_1 \,\ell\text{n}\, X_1 + \alpha_2 \,\ell\text{n}\, X_2 + \alpha_3 \,\ell\text{n}\, X_3 + \alpha_n \,\ell\text{n}\, X_n \qquad \ldots 2$$

In *Equation 2, Y* which represents output, is dependent on a number of variables such as rainfall, tapping days, wintering, *etc.* In practice, some variables like rainfall and tapping days can be quantified in specific units, whereas others like wintering, stimulation and change in tapping system cannot be measured in a similar manner. Hence, appropriate dummy variables have to be introduced in the model to represent the unquantifiable variables.

Thus, *Equation 2* has to be reformulated to take the following form:

$$\ell\text{n}Y_t = \alpha + \sum_{i=1}^{5} \beta_i \,\ell\text{n}\, X_i + \sum_{j=1}^{4} \delta_j D_j + \text{Error term} \qquad \ldots 3$$

where Y_t is the current month's yield

α is the intercept

X_1 is the previous month's yield

X_2 and X_3 are the current month's and previous month's rainfall

X_4 and X_5 are the current month's and previous month's tapping days

D_1 and D_2 represent wintering dummies, taking the value 1 for the third and fourth month respectively in a year and 0 for the other months

D_3 is the stimulation dummy, taking the value 1 for the months between January 1984 and June 1986 and 0 for the remaining period of study

D_4 represents CUT (with stimulation) dummy, taking the value 1 for the months July 1986 to December 1987 and 0 for the remaining period.

RESULTS AND DISCUSSION

Diurnal and Monthly Variations

The two-hourly average rainfall distribution patterns over the twelve-year period, 1976–87, at the RRIM Economic Laboratory are depicted in *Figures 1, 2* and *3.* Rainfall in the months of January and December was more evenly distributed over the 24-h period compared to that of the remaining months when the incidence of rainfall was mainly concentrated between 12 noon and 8 p.m.

During the first quarter of the year (January–March) and the last months of the remaining quarters of the year (June, September and December) 16%–24% of the total rainfall occurred between 6 a.m. and 12 noon *(Table 1).* This is the period of day when tapping and latex collection are carried out by the participants. Thus, during these months there was a significant drop in tapping days. Added to this, in January and December 20% and 14% of the total rainfall respectively, occurred between 12 midnight and 6 a.m. Rainfall during these hours results in the panel being too wet to tap

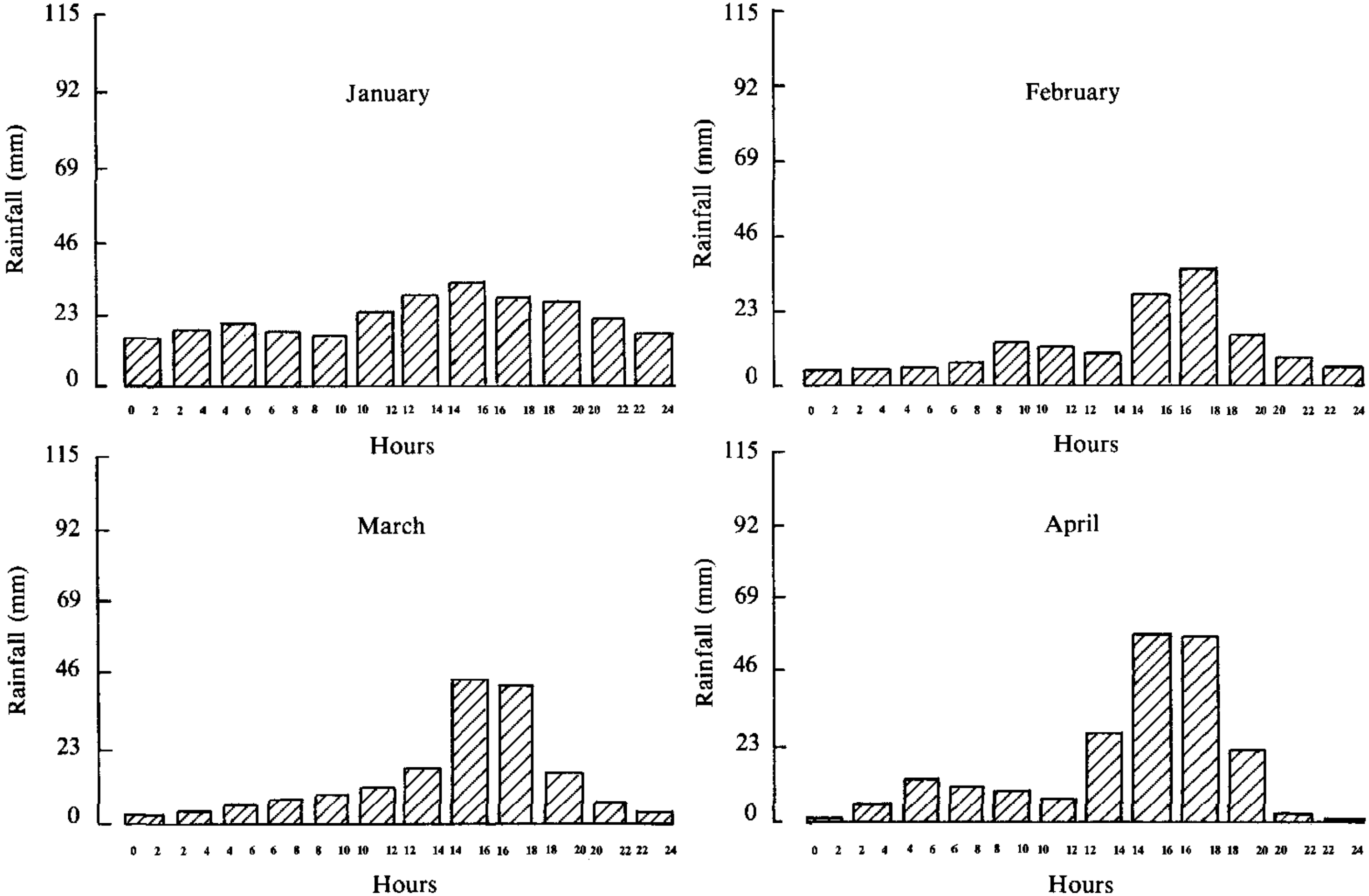

Figure 1. Diurnal variations of rainfall for January, February, March and April.

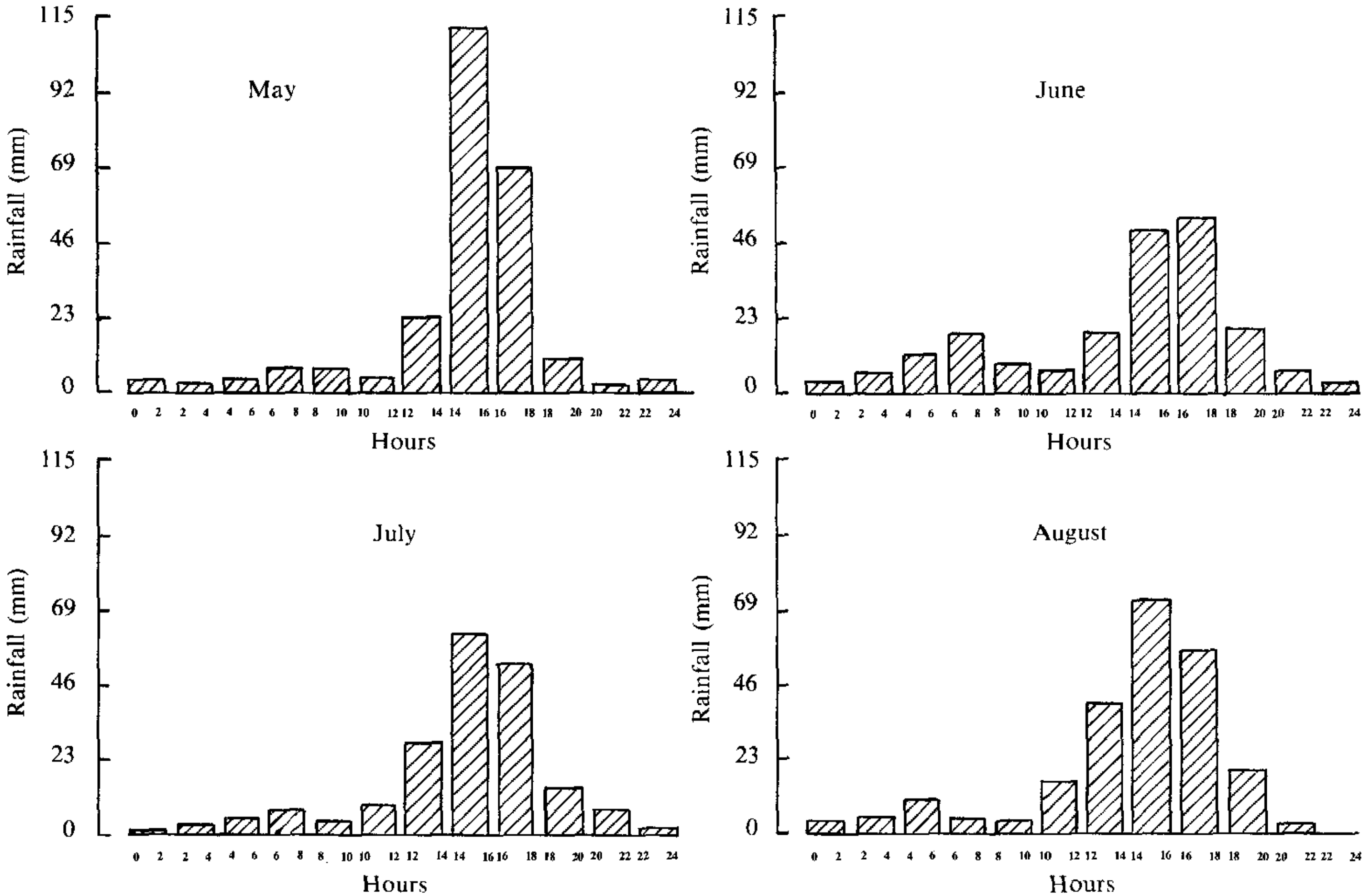

Figure 2. Diurnal variations of rainfall for May, June, July and August.

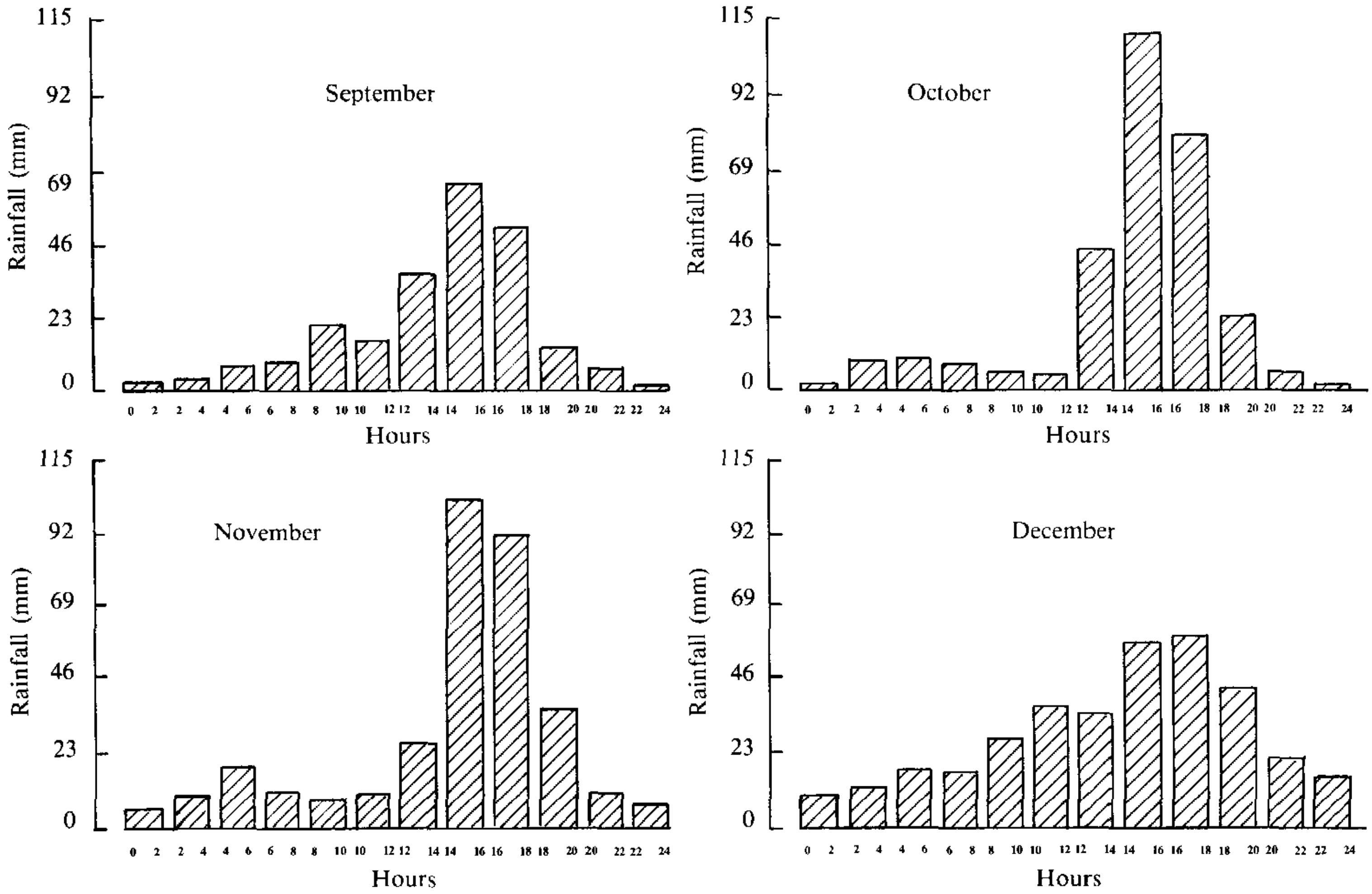

Figure 3. Diurnal variations of rainfall for September, October, November and December.

TABLE 1. AVERAGE PROPORTION OF RAINFALL OVER THE 24-H PERIOD OF THE DAY, 1976–87

Month	Average proportion of rainfall (%)			
	0–6 h	6–12 h	12–18 h	18–24 h
January	20.0	21.9	33.7	24.4
February	10.6	22.0	47.5	19.9
March	8.0	16.0	61.2	14.8
April	8.9	13.5	66.0	11.6
May	3.5	7.4	82.8	6.3
June	10.7	16.6	58.8	13.9
July	4.3	11.0	73.1	11.6
August	6.9	9.4	73.9	9.8
September	5.7	19.7	64.8	9.8
October	7.1	6.6	76.5	9.8
November	10.1	8.2	66.3	15.4
December	13.5	24.0	41.9	20.6
Annual	9.1	14.7	62.2	14.0

the following morning. Thus, causing loss of additional tapping days for these months if later tappings are not possible.

Monthly rainfall data analysis for the twelve-year period showed that the Economic Laboratory experienced heavy rain during October to January which coincides with the North-east monsoon. Of these four months, December was the wettest month with a mean rainfall of 379 mm *(Table 2)*. On the other hand, February and March were the driest months with a mean rainfall of 157–167 mm. However, year by year analyses over the twelve years showed a wide variation in the amount of rainfall during certain months; for example in January 1981, there was zero rainfall, whereas the same month in 1987 recorded the highest rainfall of 721 mm. Dale's study[7] of rainfall in Peninsular Malaysia showed that the month with the lowest rainfall had the highest coefficient of variance (C.V.) and *vice versa*. However, when the C.V. calculations were carried out this general relationship between rainfall and variability did not hold for the RRIM Economic Laboratory *(Table 2)*.

TABLE 2. DATA OF MEAN MONTHLY AND ANNUAL RAINFALL AT RRIM ECONOMIC LABORATORY, 1976–87

Month	Mean	Median	S.D.	C.V. (%)	Rain days (mean)
January	259.53	196.85	227.98	87.84	7.8
February	157.23	97.45	136.55	86.85	5.5
March	167.08	97.50	160.81	96.25	8.2
April	220.87	184.60	90.97	41.19	9.4
May	250.38	199.85	144.37	57.66	11.4
June	219.63	208.60	120.01	54.64	8.7
July	194.72	197.00	59.29	30.45	10.5
August[a]	228.63	245.30	128.07	56.02	9.1
September	254.54	247.65	75.06	29.49	12.2
October	322.23	272.35	90.85	28.19	13.3
November	334.51	296.70	154.58	46.21	14.5
December	379.37	394.35	155.55	41.00	12.3
Annual[a]	2 982.03	2 916.00	1 531.50	17.82	122.9

[a]Data for eleven years only

The mean monthly rainy days over the twelve years are also depicted in *Table 2*. A rainy day is defined as the day in which the rainfall exceeds 0.25 mm for a 24-h period. February, the driest month of the year, had the lowest mean number of rainy days (5.5 days) while November had the highest mean number of rainy days (14.5 days). September, October and December recorded a mean of twelve days or more. Since the wettest months (October to January) are also the highest yielding ones, loss in potential crop resulting from rain interference is expected to be substantial *(Table 3)*.

Regression Analysis

The regression analysis on the effects of wintering, tapping days, rainfall, CUT and stimulation on production is summarised in *Table 4*.

It is evident from *Table 4* that all the independent variables except D^3 (stimulation dummy) are significant at $P<0.05$. The variable $\ell n\ X_1$ (previous month's yield) with a coefficient of 0.3267 which is significant at $P<0.001$ indicates that the current month's production is expected to be high if the yield of the previous month is high. As expected, rainfall (variable $\ell n\ X_2$) in a month reduces tapping days and, thus depresses the yield for that month. This is supported by the coefficient of variable $\ell n\ X_2$ which is -0.0633 and significant at $P<0.01$. However, the rainfall of the previous month ($\ell n\ X_3$) has a positive effect on the production of the current month. Heavy rainfall in the previous month could have resulted in less number of tapping days; in which case, the trees would have been rested from tapping for comparatively more days. Also, the moisture content of the soil would have increased because of the heavy rainfall. These conditions would have contributed to the increase in yield for the current month. This is further supported by the variable $\ell n\ X_5$ (previous month's tapping days) with a coefficient of -0.2125, *i.e.*, if the tapping days of the last month is increased by a unit, the corresponding yield for this month is reduced by 0.2125 unit. On the other hand,

TABLE 3. MEAN YIELD, TAPPING DAYS AND POTENTIAL YIELD LOST AT RRIM ECONOMIC LABORATORY, 1976-87

Month	Yield (kg)		No. of normal tapping days	No. of tapping days lost due to		Output/ tapping day (kg)	Potential crop (kg) lost due to	
	Latex	Scrap		Rain	Leave and rest days		Rain (No tapping)	Leave
January	12 791	2 657	21	5	5	735.6	3 678	883
February	10 998	1 783	21	3	4	608.6	1 826	1 156
March	9 197	1 121	23	3	5	448.6	1 346	1 077
April	7 701	1 120	21	4	5	420.0	1 680	924
May	9 590	1 650	21	3	7	535.2	1 606	856
June	10 542	1 845	21	3	6	589.8	1 769	1 121
July	11 879	2 430	21	4	6	681.3	2 725	1 363
August	11 546	2 510	20	4	7	702.8	2 811	1 124
September	10 564	2 563	19	5	6	690.8	3 454	1 243
October	12 964	2 811	21	4	6	751.2	3 004	1 202
November	11 730	2 885	19	6	5	769.2	4 615	1 461
December	10 553	2 761	18	8	5	739.6	5 917	1 183
Annual	130 055	26 136	246	52	67	634.9	33 015	13 497

TABLE 4. COEFFICIENTS OF FACTORS AFFECTING THE PRODUCTION OF RUBBER

Variable	Coefficient	T-stat
α (constant)	5.5328***	7.563
ℓn X_1	0.3267***	4.845
ℓn X_2	−0.0633**	−2.792
ℓn X_3	0.05367*	2.201
ℓn X_4	0.5128***	6.669
ℓn X_5	−0.2125**	−2.598
D_1	−0.3106***	−4.924
D_2	−0.2742***	−4.347
D_3	−0.0635 P<0.1	−1.645
D_4	0.2090***	4.042

*Significant at $P<0.05$
**Significant at $P<0.01$
***Significant at $P<0.001$

R^2 : 0.6204

S.E. : 0.1830

Durbin-Watson: 2.168

Dependent variable: ℓn Y

Y = Production in kilogramme
X_1 = Previous month's yield
X_2 = Current month's rainfall
X_3 = Previous month's rainfall
X_4 = Current month's tapping days
X_5 = Previous month's tapping days
D_1 = Wintering dummy for month of March
D_2 = Wintering dummy for month of April
D_3 = Stimulation dummy
D_4 = CUT dummy

an increase in the number of tapping days in the current month (variable ℓn X_4) increases the yield of rubber for that particular month.

Wintering has a negative effect on the yield. The wintering months in the RRIM Economic Laboratory are March and April. Even though the negative effect of wintering on production for March is higher compared to that for April (coefficient of D_1 = −0.306 and D_2 = −0.2742 respectively), the total production in March (10 318 kg) is higher than in April (8821 kg). This difference in yield can be explained by the higher average tapping days in March (twenty-three days) compared to April (twenty-one days). The average number of tapping days lost due to rain in April was four days while in March it was three days *(Table 3)*. Furthermore, less rainfall in March (167 mm) compared to April (221 mm) also contributed to the higher production in March *(Table 2)*.

Stimulation with ½S d/2 tapping system was introduced in the Economic Laboratory in January 1984. This system was practised until the middle of 1986. Regression analysis showed that the application of yield stimulants had a negative effect on the production rather than a positive one (the coefficient of D_3 = −0.0635). This negative effect which is significant at $P<0.1$ can be attributed to the high incidence of brown bast reported in the scheme (approximately 20%), non-completion of the tasks which in turn resulted in a high number of untapped trees and improper application of yield stimulants by some of the participants. Due to the high incidence of dryness (brown bast) in the base panels, CUT with stimulation was introduced in July 1986. The coefficient of the variable D_4 (CUT dummy) of 0.2090, which is significant at $P<0.001$, indicated that CUT with stimulation had a positive effect on the yield of trees.

Further, the regression analysis showed that the selected factors namely rainfall, tapping days, wintering and stimulated tapping systems explained approximately 62% (R^2 = 0.6204) of the total variation in the production of rubber in the RRIM Economic Laboratory. The remaining 38% of the production variation could be due to other factors such as age of the trees, soil fertility, daily variation of temperature, *etc.*, which have not been considered in this study.

CONCLUSION

The extent to which rainfall interferes with the tapping process depends on its diurnal variation and intensity. Thus, a proper understanding of rainfall pattern in a given locality will assist the rubber grower to minimise his loss of crop due to rainfall. Heavy rain which falls during the night wets the tapping panel, which in turn results in late tapping or non-tapping the following day depending on the intensity of panel wetness. In this situation, the grower can minimise his loss of crop by introducing rain-guards on the trees[8]. Presently, these rain-guards are of no help when rain occurs between 6 a.m. and 12 noon which cause partial or complete washout of the crop if tapping of the trees has commenced. Thus, there is a need for research on preventive methods that would minimise crop loss during tapping and collection time. In spite of crop loss due to rain, output can be improved if appropriate exploitation techniques and tapping systems together with the use of stimulants are adopted.

ACKNOWLEDGEMENT

The authors wish to express their thanks to the RRIM Economic Laboratory Committee for making available the required data for this study. Special acknowledgement is also due to Dr Mohd. Yusof bin Shahabuddin, Head, Applied Economics and Statistics Division, RRIM, for his encouragement.

July 1988

REFERENCES

1. WYCHERLEY, P.R. (1963) Variation in the Performance of *Hevea* in Malaya. *J. trop. Geogr.*, **17**, 143.
2. HARIDAS, G. AND SUBRAMANIAM, T. (1985) A Critical Study of the Hydrological Cycle in a Mature Stand of Rubber. *J. Rubb. Res. Inst. Malaysia*, **33(2)**, 70.
3. JAMES NAYAGAM, ABRAHAM, P.D. AND YONG, H.W. (1986) Economic Returns from Selected Stimulated Tapping Systems. *Proc. Int. Rubb. Conf. Kuala Lumpur*, **3**, 527.
4. VANAJA, V., YUSOF, M.S., PHANG, A.K. AND RAWIAN, M.A. (1987) Controlled Upward Tapping with Stimulation: Preliminary Results. *Plrs' Bull. Rubb. Conf. 1985 Kuala Lumpur*, **3**, 527.
5. ARIFFIN BIN MOHD. NOR AND JAMES NAYAGAM (1984) *Incentive Wage Concept: An Alternative Approach to Land Development Schemes in Malaysia*. Kuala Lumpur: Rubber Research Institute of Malaysia.
6. DILLON, J.L. (1968) *The Analysis of Response in Crop and Livestock Production*. Sydney: Pergamon Press (Aust.) Pty. Ltd.
7. DALE, W.L. (1960) The Rainfall of Malaya, Part II. *J. trop. Geogr.*, **14**.
8. CHEW, O.K., GAN, L.T., *et al.* (1986) A New Rainguard Technique (Ebor Eaves) for Improving Exploitation of Rubber. *Proc. Int. Rubb. Conf. 1985 Kuala Lumpur*, **3**, 425.