Indian Journal of Natural Rubber Research, **6** (1&2) : 105-110, 1993

EFFECT OF ASPECT ON SOIL TEMPERATURE AND GROWTH OF *HEVEA* ON HILLS OF NORTH EAST INDIA

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Saseendran, S. A., Mandal, D., Sinha, R. R., Vijayakumar, K. R., Potty, S. N. and Sethuraj, M. R. (1993). Effect of aspect on soil temperature and growth of *Hevea* on hills of North East India. *Indian Journal of Natural Rubber Research*, **6** (1&2) : 105-110.

Effect of aspect on soil temperature and growth of *Hevea* trees on a gently undulating terrain (slope about 25°) of North East India was studied. Soil temperatures under *Hevea* at depths 5, 10 and 20 cm on a south facing slope was found to be significantly higher than that on a north facing slope during the winter months. The difference in temperature was not found to exist during the summer months. Slope orientations were also found to influence the growth of *Hevea* trees. Girth of the trees on the south facing slope was observed to be significantly higher than on the north facing slope. At the end of 6th year of planting, a mean difference of 9 cm in girth of the trees on these aspects was observed.

Key words : *Hevea brasiliensis*, Soil temperature, Aspect, North East India.

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INTRODUCTION

In India, rubber (*Hevea brasiliensis*) cultivation was traditionally confined to the tropical regions of the states of Kerala, Tamil Nadu and Karnataka within the latitude 12°N. With the increasing demand for natural rubber, its cultivation has been extended to latitudes upto 28°N where the crop is confronted with different stress factors. Soil temperature is a major factor controlling tree growth. Water uptake through roots, root growth, plant water stress etc. are controlled by low soil temperatures (Lopushinsky and Kaufman, 1984). It was also found to control stomatal openings (Lopushinsky and Max, 1990). Temperature is reported to be decisive in stand growth of forest with increasing latitude (Heikurainen and Seppala, 1965; Koivisto, 1971; Laine and Starr, 1979).

Physiographic factors like slope, drainage, soil depth and texture of soil were found to affect the performance of *Hevea* in Malaysia (Chan *et al.*, 1972). In the present study an attempt has been made to analyse soil temperature characteristics under rubber plantations on northfacing and southfacing slopes in the hill terrains of North East India and to quantity the effect of aspect of slope on growth of *Hevea*.

MATERIALS AND METHODS

The experiment was conducted in

Presented in the International Natural Rubber Conference, 5-8 February 1992, Bangalore, India.

the farm of the Rubber Research Institute of India, Regional Research Station, Sarutari (latitude 26°35'N, longitude 90°52'E, altitude 155 m above msl). Soil temperature observations were made on north and south facing slopes which have about 25 per cent slope. The area supports six year old rubber trees of different clones planted in 1985 in a randomised block design at a spacing of 6.1 x 3.5 m. The trees planted on both the aspects were maintained under the same agromanagement practices. Mean annual rainfall is of the order of 180 cm spread over 130 days. Winter minimum temperature varies between 5 and 15°C and summer maximum between 26 to 38°C. Mean relative humidity varies between 55 to 90 per cent.

Soil temperature observations were made under bare soil on contour terraces in between trees planted on the south and north facing slopes. Observations were recorded at 5, 10 and 20 cm depths during the period between January and August 1991, at 04.00, 07.00 and 14.00h LMT. Weekly analysis and soil temperature was made for winter, pre-monsoon (transition season) and summer seasons. Tree girth of ten *Hevea* clones was collected every February, May, August and November during the period 1988 to 1991.

RESULTS AND DISCUSSION

Effect of aspect on soil temperature

Winter season

The minimum and maximum air temperature during the period 1st January to 25th March, which represents typical winter condition in the region, ranged from8.8 to 16.9°C and 21.5 to 32.6°C respectively (Table 1). Rainfall was scanty (3.5 cm) and had no influence on the air and soil temperature. Soil temperature on the south facing slope was found to be significantly higher than on north facing slope (Table 2), the difference being maintained throughout the day at all depths. This is explained by the differential capture of solar radiation by land terrains of different slopes and aspects modifying soil heat flux and soil temperature. The importance of slope and aspect increases with latitude due to the increasing solar declination during winter months. During this season the south facing slopes are warmer than north facing slopes in the northern hemisphere. The importance of slope and aspect in modifying the microclimate of a location is more critical in the higher latitudes than in the tropics where the sun remains high throughout the year.

Mean weekly soil temperature observed during this season (Table 3) also indicated higher soil temperatures on the south facing slopes at all three depths. This may contribute to better growth of the *Hevea* trees on south facing slopes than north facing slopes, as evident from the girth observations (Table 4).

The pattern of variation in soil temperature on south and north facing slopes were found to be similar (3-6°C) with a maximum reaching around 15.00 h and a slow decrease after 16.00 h. On south facing slope the diurnal soil temperature fluctuation was between 16-22°C and on north facing slope 12-16°C.

Transition season

This period (26 March - 19 May) represents the typical transition season in NE India from the cool winter season to the hot summer season. During this period minimum air temperature ranged from 16.6 to 24.5°C and maximum from 27.6 to 32.9°C (Table 1). Rainfall received during this period amounted to 24 cm.

Table 1. **Weekly weather of the experimental location**

Standard weeks		Air temperature (°C)		Relative humidity (%)		Rainfall (mm)
		Maximum	Minimum	06.20 (IST)	13.20 (IST)	
Winter season						
January	1	21.5	11.2	92.0	79.0	0.0
	2	23.9	10.9	89.5	58	0.0
	3	22.6	9.6	35.5	55.2	0.0
	4	25.3	8.8	87.5	68.1	0.0
	5	25.4	12.6	87.0	68.1	0.0
February	6	26.1	12.6	56.1	65.1	2.8
	7	27.6	12.5	90.0	50.7	0.0
	8	29.4	12.8	86.4	47.7	0.0
	9	28.5	14.4	88.0	60.0	0.0
March	10	29.6	13.9	88.0	58.0	2.2
	11	31.7	16.7	91.5	57.2	10.2
	12	32.6	16.9	72.4	41.5	20.0
Transition season						
	13	30.5	16.6	90.7	56.7	26.2
April	14	27.6	18.7	93.0	67.8	40.6
	15	30.7	17.9	85.1	63.0	23.0
	16	34.1	17.7	74.4	44.0	2.2
	17	30.9	19.6	73.1	70.1	11.0
	18	26.8	20.3	90.0	74.7	91.2
May	19	28.1	21.7	92.7	87.2	48.7
Summer season						
	20	28.9	20.8	88.5	81.7	57.2
	21	31.0	22.0	93.4	77.2	17.6
	22	31.2	22.3	93.0	87.7	114.9
June	23	31.9	23.8	94.8	68.5	60.4
	24	30.2	24.4	96.0	90.4	55.5
	25	32.2	24.2	93.7	82.4	41.7
	26	32.9	24.2	95.4	88.0	67.2
July	27	30.72	24.5	96.0	92.0	97.2
	28	32.40	24.1	95.0	84.1	39.0

Table 2. **Effect of aspect on soil temperature**

Aspect	06.20 IST			13.20 IST		
	5 cm	10 cm	20 cm	5 cm	10 cm	20 cm
Winter season						
North facing	15.93	16.6	17.1	19.2	18.3	17.9
South facing	18.81	18.9	21.8	26.2	24.5	23.3
SE ±	0.68	0.69	0.62	0.88	0.77	0.60
C. D. (P=0.01)	2.42	2.45	2.2	3.12	2.73	2.15
Transition season						
North facing	21.5	22.1	22.9	25.1	24.2	23.2
South facing	22.1	23.1	24.3	28.2	26.6	25.1
SE ±	0.71	0.67	0.63	0.69	0.49	0.46
C. D. (P=0.01)	NS	NS	NS	2.6	1.9	NS
Summer season						
North facing	25.8	25.9	26.2	28.2	27.4	26.4
South facing	25.8	26.1	26.6	28.4	27.6	27.1
SE ±	0.53	0.49	0.57	0.67	0.48	0.51
C. D. (P=0.01)	NS	NS	NS	NS	NS	NS

During this period significant difference in temperature of soil under *Hevea* due to aspect was found only at 13.20 IST at 5 and 10 cm depths (Table 2). At these depths temperature on the south facing slope was higher than that on the north facing slope by 0.5 to 6.2°C and 0.7 to 4.6°C respectively. The decrease in the difference in soil temperature between these aspects is explained by the decrease in declination of the sun at these latitudes after the winter solistice. The mean weekly soil temperatures observed during this period are presented in Table 2. As the season progresses into summer the differential effect of aspect in modifying the microclimate diminishes. Diurnal soil temperature range was found to be confined between 20-23°C on both the aspects. Hence during this period stress to the trees due to diurnal soil temperature fluctuations will be less.

Summer season

Summer season in the region is confined to the period May to July. Mean weekly maximum air temperature during the period 7th May to 15th July varied from 28.9 to 32.9°C and minimum 21.0-24.5°C (Table 1). There was no significant difference in soil temperature between the two aspects during the summer (Table 2). As the higher soil temperature observed during winter season on the south oriented slopes, was not found to exist in summer, no adverse effect to the *Hevea* trees was noticed. The diurnal temperature fluctuations in the soil during this season ranged from 26°C to 31°C on both the aspects.

Effect of aspect on growth of *Hevea*

Mean girth of the ten clones grown on the north and south facing slopes under

emperature variations on south facing (S) and north facing (N) slopes during winter months (January to March) (°C)

e and k No.			Winter 6.20 IST						13.20 IST					
			5 cm		10 cm		20 cm		5 cm		10 cm		20 cm	
			N	S	N	S	N	S	N	S	N	S	N	S
nuary	1-7	(1)	13.6	14.8	14.5	15.7	16.3	18.2	15.9	24.2	15.6	22.2	15.6	20.3
nuary	8-14	(2)	13.3	17.5	14.5	18.1	15.5	20.5	17.0	22.9	16.6	21.5	19.2	22.9
nuary	15-21	(3)	13.2	17.1	14.2	16.2	15.3	18.7	15.7	22.7	14.9	21.4	15.0	20.2
nuary	22-28	(4)	12.8	16.4	13.2	16.9	14.2	21.5	15.3	24.4	14.5	21.5	14.5	21.9
bruary	29-4	(5)	15.5	18.7	15.9	19.1	16.5	21.5	17.7	23.0	16.8	22.2	16.5	21.9
bruary	5-11	(6)	15.6	17.5	16.4	18.2	17.6	20.3	18.5	23.5	17.9	22.9	16.9	22.3
bruary	12-18	(7)	16.4	19.5	17.1	20.1	18.3	22.5	19.2	27.9	18.3	25.8	17.5	23.9
bruary	19-25	(8)	15.9	19.8	16.2	20.5	17.5	23.0	21.5	30.4	20.2	27.8	18.5	24.2
arch	26-4	(9)	17.9	20.5	18.6	20.9	19.4	23.5	21.9	28.7	20.5	26.8	19.5	24.2
arch	5-11	(10)	17.4	20.1	18.2	20.7	19.2	23.3	21.6	29.3	20.2	27.1	19.5	26.6
arch	12-18	(11)	19.8	22.0	20.2	22.3	20.8	23.8	23.3	28.9	22.1	27.1	20.7	26.3
arch	19-25	(12)	19.7	21.9	20.5	22.7	21.5	27.7	23.0	29.1	22.1	27.6	21.3	25.4
oril	26-1	(13)	19.4	21.6	20.1	22.7	20.9	24.7	23.2	29.4	22.2	26.8	21.0	25.2
oril	2-8	(14)	21.3	21.9	21.5	22.7	21.9	24.5	24.1	28.5	23.5	25.5	22.9	24.4
oril	9-15	(15)	21.1	21.8	21.6	22.8	22.6	23.9	24.9	30.5	24.0	28.1	22.8	25.6
oril	16-22	(16)	21.9	22.3	23.1	23.5	24.5	24.9	27.9	29.2	26.3	28.4	25.0	25.6
oril	23-29	(17)	23.0	23.7	22.9	23.7	24.0	24.8	26.4	29.2	25.5	27.9	24.2	26.2
ay	30-6	(18)	22.3	22.8	22.6	23.4	23.4	24.0	23.9	25.0	23.6	24.7	23.2	24.4
ay	7-13	(19)	22.2	22.6	22.5	22.9	23.0	23.6	25.4	25.9	24.4	25.1	23.6	24.4
ay	14-20	(20)	23.1	23.5	23.3	24.2	23.8	24.5	25.6	26.6	25.2	25.9	24.7	25.4
ay	21-27	(21)	24.3	24.5	24.5	24.9	24.9	25.4	27.4	28.4	26.2	27.2	25.0	26.0
ne	28-3	(22)	25.2	25.2	25.3	25.6	25.8	26.1	27.0	28.1	26.0	27.6	24.9	26.9
ne	3-10	(23)	26.1	25.9	26.8	26.2	26.3	26.6	29.0	29.4	28.1	28.2	26.4	27.1
ne	11-17	(24)	26.7	26.5	26.6	26.6	26.8	27.0	28.5	28.1	27.8	27.7	27.8	27.1
ne	18-24	(25)	26.8	26.7	26.8	26.9	27.0	27.5	29.1	28.9	28.3	28.3	27.3	27.8
y	25-1	(26)	27.0	26.9	27.1	27.4	27.5	28.1	29.8	29.3	28.9	28.9	27.8	28.3
y	2-8	(27)	26.8	26.8	26.9	27.1	27.4	27.8	28.8	28.5	28.3	27.9	27.3	27.8
y	9-15	(28)	26.7	26.6	27.2	26.9	27.3	27.8	29.2	29.2	28.4	28.5	27.4	28.1
y	16-22	(29)	27.0	26.9	27.3	27.2	27.6	27.9	29.6	29.5	28.8	28.8	27.8	28.1

Table 4. Effect of aspect on growth of *Hevea*

Aspect	Girth in cm												
	1988				1989				1990			1991	
	Feb.	May	Aug.	Nov.	Feb.	May	Aug.	Nov.	Feb.	May	Aug.	Nov.	Feb.
North facing (Mean)	13.97	14.73	16.55	19.23	19.86	21.88	23.28	26.50	27.05	28.10	30.10	32.47	32.84
South facing (Mean)	22.45	23.49	25.50	28.17	28.81	30.69	32.92	35.30	35.80	36.77	38.81	41.38	42.03
SEm±	0.46	0.47	0.49	0.44	0.43	0.45	0.65	0.45	0.44	0.48	0.45	0.47	0.45
CD (P=0.01)	1.61	1.63	1.65	1.48	1.47	1.52	2.19	1.52	1.48	1.64	1.52	1.58	1.54

similar agromanagement practices is pre sented in Table 4. Girth of trees grown or the south facing slope was found to be significantly higher than those on the north facing slope. The higher girth can be attributed to the higher soil temperatures during the winter season.

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