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EFFECT OF IRRIGATION ON GROWTH AND OTHER PHYSIOLOGICAL PARAMETERS OF HEVEA BRASILIENSIS IN THE KONKAN REGION OF INDIA

C.V.S. Bhaskar, T. Mohan Krishna, T.R. Chandrasekhar,
P. Sanjeeva Rao, K.R. Vijayakumar and M.R. Sethuraj
Rubber Research Institute of India.

ABSTRACT

An irrigation experiment was laid out in the Konkan region of India, which is identified as being marginally suitable for extension of *Hevea* cultivation. Irrigation has been found to be essential for the maintenance of optimum growth under the stress of the prevailing environmental conditions. Seven irrigation treatments (three basin, three drip and a non-irrigated control) were imposed on clone RRII 105.

There was negligible growth in the non-irrigated plants during the dry season. Irrigation resulted in significant increases in growth to the extent that more than 50 per cent of wet season growth could be achieved by basin irrigation. The girth increment and relative growth rate showed a positive relationship with the quantities of water applied. There was no significant difference in the photosynthetic rates, stomatal characteristics and girth increments during the wet season among the plants in different treatment plots. About 85% decrease in photosynthetic rate was observed in non-irrigated plants due to the severe stress conditions. The maximum rate of basin irrigation would enable trees to maintain only fifty per cent of the photosynthetic rates found during the wet season.

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Introduction

The North Konkan region, lying in the Western part of India, represents dry-wet tropical climatic conditions. Efforts are under way to extend rubber cultivation into this region. The major constraint for rubber cultivation is the perennial lengthy period of drought coupled with a high atmospheric temperature (of the order of 40°C for a few days) and low relative humidity (less than 60%) with dry winds. The evaporation rates during November to May are of the order of 4 to 9mm per day. This region, however, also gets more than 2500mm of rainfall although this is confined to the southwest monsoon period. The large diurnal and seasonal variations in the ambient temperature necessitate the use of *Hevea* plants adapted to the local microclimate. Growth inhibition in the initial years could be overcome by life-saving irrigation (1, 2). Omont (3) reported a possible reduction of the immaturity period by 18 months with irrigation (IW/CPE = 0.9).

The initial results of an experiment laid out to study the effects of irrigation on growth and other physiological parameters of immature *Hevea* are discussed.

Materials and methods

The experiment was laid out in 1989 in the Regional Research Station Farm, Dapchari (20° 04' N, 72° 04' E, alt 48m). The planting material selected was clone RRII 105 which was planted out in 1987 after being raised in polybags for nine months. The spacing is 4.9 x 4.9m in a plain land. The soil type is lateritic (FC = 30.5%; PWP = 17.2%). Fertilizer application and other cultural practices were in accordance with the package of practices and recommendations. Life saving irrigations were provided uniformly during the dry season over the first two years.

A total of seven irrigation treatments were used with a randomized block design and three replications with each square plot consisting of 25 plants. The treatments comprise control (T_1 = no irrigation), three levels of basin irrigations (T_2 = 1.00, T_3 = 0.75 and T_4 = 0.50 ET) and three levels of drip irrigations (T_5 = 0.75, T_6 = 0.50 and T_7 = 0.25 ET). The potential evapo-transpiration (ET) values were estimated by a modified Penman equation (4). The quantities of water for basin irrigation and the scheduling of irrigation were calculated as reported earlier (5). Drip irrigation was provided daily with different quantities of water. The basin irrigation system consisted of sub-surface pipelines, quick coupling aluminium pipes and flexible hose pipes. For drip irrigation, main and lateral pipes are of PVC and LDPE respectively. Pressure compensated drippers (4 l/hr.) were used. Heavy mulch was provided to all plants in the basins. In addition to life-saving irrigation, differential basin irrigation was provided for 20 days during May-June 1989. In the third year both basin and drip irrigations were given from the last week of December 1989 to the last week of May 1990.

Girth recordings were made at 150cm above bud union on nine plants in each plot at 15 day intervals. Relative growth rate (RGR) was estimated after calculating the biomass following the method described for *Hevea* by Shorrocks (6).

Observations on photosynthesis and associated parameters were made using the LI-6200 portable photosynthesis system (Lambda Instruments, USA) on three representative days covering three distinct seasons. Three plants were sampled in each treatment and in each plant the youngest fully mature whorl was selected for recording. The parameters were observed in the middle leaflets of two leaves in the middle of the whorl. Diurnal observations were made in each season to identify the peak periods of photosynthetic rate and measurement time in each season coincided with the peak hours of photosynthesis for that sea time in each season coincided with the peak hours of photosyntesis for that season. The parameters recorded were photosynthetic rate (A), transpiration rate (E), stomatal diffusive conductance (G_s), inter-cellular CO_2 concentration (C_i), stomatal resistance (R_s), air temperature (T), vapour pressure deficit (VPD) and photosynthetic photon flux density (PPFD). Soil moisture percentage near the root zone of control plants were recorded gravimetrically on the days of observation. Data obtained were statistically analysed.

Results and discussion

The mean absolute girth of plants under various treatments were recorded in October 1989 and May 1990. The girth increment and RGR during June-October of 1989 and January-May 1990 periods are presented in Table 1. In October 1989, the absolute girth of plants in control plots were 1.26 and 1.28cm less than plants in treatments T_3 and T_4. The small amount of advantage observed in the girth attained by plants receiving basin irrigation treatments by this time might be due to the few irrigations given in the previous dry season. However, the girth increment attained by plants under different treatments in the wet period were not significanttly different from each other. A similar trend was observed with respect to RGR also.

The effects of irrigation throughout the full dry season on growth is evident from the girth increment attained in the January to May period of 1990. The control plants showed practically no growth during this period whilst, significantly, higher absolute girth was found only with basin irrigation. However, when girth increment is considered the increment obtained with T_5 also becomes significantly more than that of the control. In the basin irrigation treatments though, there was no statistically significant difference in the girth increment attained; there was a positive relationship between the girth increment and quantity of water applied. However, a significant difference between irrigation treatments could be observed when RGR is considered, the rates increasing with higher quantities of water applied. Even with T_2, the RGR obtained is only around half that of wet season value. This indicates that the water requirement in the early years of growth might be much higher than the full irrigation given, assuming a crop coefficient (k_c) of 1.0. The inconsistent results obtained with drip irrigation were due to frequent failures encountered in the system.

Data on photosynthesis and other associated parameters are presented in Table 2. In the wet season the peak rate of photosynthesis was observed between 8.30 and 10.00 h. In the dry season (January and April), the peak rate was observed between 8.00 and 9.00 h. The shifting of the peak period in the dry season is due to earlier stomatal closure resulting from stress conditions. Because of the shift, the VPD, PPFD and T were low at the time of the dry season observations.

The physiological parameters observed in this location in the wet season had values comparable to those observed in the traditional region in the corresponding season (unpublished). In the experimental area the rate of photosynthesis and other parameters were found to be uniform in all plants. The mean A is 10.12 μmole. m^{-2}. s^{-1}, which is concomitant with other observed parameters such as G_s and E, maintaining the steady state of C_i.

A marginal decline in soil moisture had occured by December. Even though irrigation was started on 27 December, low A was observed in the second week of January 1990. Mean E rates were decreased to a great extent, from 8.6 to 2.8 mmole. m^{-2}. s^{-1}, indicating the initiation of drought conditions. The stomatal resistance (R_s) was increased causing the lower G_s value and thereby a lower C_i value. Though appreciable variations in C_i were not there, a marked decrease in the A rates observed may be due to the soil moisture stress.

In contrast, imposition of different levels and methods of irrigation resulted in significant variations in the physiological characteristics in the extreme dry conditions (Table 2). In the control plots where the soil moisture levels were below the wilting point, up to 90cm depth, about 85 per cent decrease in A was observed over the wet period. Under moderately higher G_s condition, the A was reduced considerably due to the prevailing moisture stress. Earlier stomatal closure was observed in the control plants indicating the avoidance of moisture stress to conserve the leaf water, which might have lead to the higher G_s in the leaves. The high C_i also indicates the building up of CO_2 concentration. Further, the plants under stress showed accelerated shedding of leaves, thereby reducing the leaf area during the summer months, whereas the leaf shedding rate was low or negligible when water was available from irrigation.

In April, a higher rate of A was observed due to full irrigation (T_2) to the plants indicating the efficient performance of *Hevea* plants under atmospheric stress conditions. In T_3 (75% irrigation), because of the optimum G_s over T_2, higher C_i was maintained, which was associated with the lower rate of A. The lower A observed under 50% irrigation (T_4) can be attributed to the very high R_s. This may be due to the lower quantity of water applied or to delays in irrigation thereby exposing the plants to alternate stress and recovery phenomina.

Due to the continuous supply of varied quantities of water through the drip irrigation system, the plants were maintained under balanced physiological conditions. Reduction in the quantity of water applied was reflected in the consequent reduction in R_s and C_i, and increase in G_s and E rates. The significant differences observed in the RGR under varied moisture levels are in agreement with the observed physiological parameters. This study also indicates that under higher ambient T, VPD and PPFD, ample supply of irrigation can improve the girth increment and overall physiological status of the plant.

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Table 1: *Growth performance of Hevea* (RRII 105) in wet and dry seasons with different irrigation treatments

Treat-ments	WET SEASON Girth in Oct 1989 (cm)	WET SEASON Girth increment (cm)	WET SEASON R G R* (g kg^{-1} $season^{-1}$)	DRY SEASON Girth in April 1990 (cm)	DRY SEASON Girth increment (cm)	DRY SEASON R G R (g kg^{-1} $season^{-1}$)
T_1	14.46	3.31	722.43	14.85	0.08	14.79
T_2	14.94	3.71	625.26	17.89	1.97	325.00
T_3	15.72	3.48	697.42	18.03	1.69	274.67
T_4	15.74	3.27	647.50	17.30	1.13	189.19
T_5	13.80	3.81	910.80	15.69	1.27	265.60
T_6	14.66	4.18	938.27	15.42	0.62	65.89
T_7	14.53	3.84	860.82	15.68	0.72	123.31
$C.D_{0.05}$	1.213	ns	ns	1.887	0.972	39.04

* Relative growth rate for 5 months : ET is crop evapotranspiration

T1 - Control (no irrigation), T2 - Basin 1.00 ET, T3 - Basin 0.75 ET,

T4 - Basin 0.50 ET, T5 - Drip 0.75 ET, T6 - Drip 0.50 ET, T7 - Drip 0.25 ET

Table 2: ***Physiological characteristics of Hevea*** **(RRII 105) under different soil moisture regimes**

Treatment	November 1989					January 1990					April 1990				
	A	E	G_s	C_i	R_s	A	E	G_s	C_i	R_s	A	E	G_s	C_i	R_s
T_1	12.98	9.7	433.0	250	0.93	6.31	1.6	90.2	214	4.30	1.94	0.66	70.4	242	6.64
T_2	10.84	9.8	332.1	243	1.18	6.93	2.2	113.3	225	3.72	6.40	1.60	94.6	219	4.79
T_3	8.50	6.0	181.5	254	2.13	10.67	4.4	186.1	215	2.27	3.77	1.07	85.0	251	4.06
T_4	8.88	8.5	284.9	240	1.38	8.71	2.9	134.1	215	3.06	1.97	0.43	82.4	213	16.35
T_5	11.59	9.2	306.8	251	1.29	4.58	2.7	87.2	231	4.65	3.19	0.77	27.8	120	12.33
T_6	8.91	8.0	248.6	232	1.60	6.64	2.6	101.6	220	3.96	2.62	1.46	39.8	208	9.94
T_7	9.17	9.2	281.6	242	1.39	4.14	3.0	78.4	225	5.12	4.24	1.83	65.2	222	9.30
Mean	10.12	8.6	295.5	244	1.41	6.85	2.8	113.0	221	3.86	3.45	1.12	66.0	211	9.20

Soil - Climatic Factors	November 1989	January 1990	April 1990
Air Temperature (°C)	34.91 ± 0.85	27.89 ± 2.63	31.08 ± 2.57
Vapour pressure deficit (KPa)	2.89 ± 0.28	2.15 ± 0.62	1.95 ± 0.74
Photosynthetic photon flux density (μE m^{-2} s^{-1})	1600 - 1700	1300 - 1500	1100 - 1400
Soil moisture (depth: 0-30 cm) in control plots	29.03%	24.43%	13.61%

A: Photosynthetic rate (μ mole m^{-2} s^{-1}); E: Transpiration rate (m mole m^{-2} s^{-1}); R_s: Stomatal resistance s cm^{-1}); G_s: Diffusive conductance (m mole m^{-2} s^{-1}); C_i: Intercellular CO_2 concentration (ppm);

Treatments T_1 to T_7 are as per able 1.