RESPONSE OF RUBBER (*HEVEA BRASILIENSIS*) SEEDLINGS TO IRRIGATION IN NURSERY

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A study on the response of rubber seedlings to five moisture regimes (0,25,50,75 per cent depletion of available soil moisture and unirrigated control) indicated 50 per cent depletion of available soil moisture to be the permissible level for optimum growth of seedlings. The growth attributes such as average leaf area, total aboveground biomass, length of the internode, number of leaves per whorl and whorl number were found to be significantly affected by moisture stress. Average seasonal and daily consumptive use and crop factor for the irrigation period were also worked out for the different moisture regimes.

Key words: Consumptive use, Crop factor, Growth, Irrigation, Seedling nursery, Soil moisture depletion.

Irrigation of ground nurseries has been reported to be beneficial even under conditions of well-distributed rainfall (Webster, 1989; Haridas, 1980; 1985) when application of small amounts of water during the dry spells improved growth. In regions with distinct dry periods growth will not be satisfactory unless nurseries are regularly watered during the dry season. Irrigation is useful in rubber nurseries during the summer even in traditional areas where it is preferably given once in two to three days (Punnoose and Lakshmanan, 2000). Information available on the extent of moisture deficit that can be tolerated by the seedlings, the frequency of irrigation required, the evapotranspiration / consumptive use of water and the water requirement of rubber in seedling / ground nursery is limited. Hence a field experiment was initiated to study the response of rubber seedlings to irrigation in a seedling nursery.

The experiment was laid out in the farm of the Regional Research Station of the Rubber Research Institute of India, located at Padiyoor, Kannur District in North Kerala (11° 58'N and 75° 36'E). The experimental site was at an altitude of 20 m above MSL. Germinated seeds were collected from the germination beds and planted in seedling beds at a spacing of 30 x 30 cm during August 1999. All cultural operations as per the recommended package of practices for seedling nursery were adopted. The soil of the experimental site was clay loam with a bulk density of 1.32 Mg/m^3, field capacity 28 per cent and permanent wilting point of 17.5 per cent. The treatments were imposed from the middle of December after the cessation of the North East monsoon rains. Uniform irrigation was given to all the plots on December 16^{th} to bring the soil to field capacity level, which was followed by the imposition of the different moisture regimes.

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Irrigation schedules were fixed on the basis of depletion of soil moisture. Five moisture regimes were imposed *viz.*, daily irrigation, irrigation at 25%, 50%, 75% depletion of available soil moisture (DASM) and an unirrigated control. The depth of the root zone was assumed as 30 cm since root concentration is maximum at the surface. Based on this, the volume of water to be applied to bring the soil to field capacity level was calculated. The experiment was laid out in RBD with three replications. The plots were 1.2 x 10 m seedling-beds with four seedling-rows. The central two rows of seedlings were selected for growth measurements. Growth observations were recorded from 20 seedlings avoiding plants on the borders. Pre-treatment observations were recorded before commencement of irrigation. Changes in soil moisture were monitored regularly before and 24 h after each irrigation by collection of soil samples. Soil moisture content was determined by the gravimetric method. Ground water was not accounted for as the water table was beyond 2 m from the surface.

The consumptive use of soil water was calculated from the soil moisture determined prior to and 24 h after irrigation. Correction was made for enhanced water loss for the period within 24 h after irrigation. Effective rainfall for the period of study was determined based on the soil moisture content and the potential evapotranspiration (Ep) rates (Dastane, 1974). The weather data pertaining to the station for the period of study is given in Table 1. Irrigation was discontinued from May due to frequent occurrence of rains. The details with respect to the number of irrigations and the total quantity of water applied are given in Table 2.

Table 1. **Weather during the study period (1999-2000)**

Month	Total rainfall (mm)	Number of rainy days	Mean temperature (°C)		Relative humidity (%)		Mean evaporation (mm/day)
			Max.	Min.	FN	AN	
December	-	-	33.6	20.9	83	9	4.2
January	-	-	34.8	18.7	82	37	4.8
February	-	-	36.4	20.4	85	30	4.8
March	-	-	36.9	22.8	85	39	5.8
April	40.0	2	35.2	23.2	84	50	4.9
May	434.8	18	31.0	22.9	91	72	4.4

Table 2. **Details of irrigation**

Treatment	Depth of pre-treatment irrigation (mm)	Number of irrigations given						Depth of irrigations (mm)	Effective rainfall (mm)	Total water applied + effective rainfall (mm)
		Dec	Jan	Feb	Mar	Apr	Total			
Daily irrigation	50	14	25	22	26	24	111	5.9	40.0	744.9
25% DASM	50	4	7	7	8	7	33	10.3	17.6	407.5
50% DASM	50	2	4	4	5	4	19	20.6	13.0	454.4
75% DASM	50	1	2	2	2	2	9	30.9	40.0	368.1
Unirrigated	50	-	-	-	-	-	-	-	40.0	90.0

The data on diameter of stem and plant height recorded at periodic intervals is presented in Tables 3 and 4. The plant diameter values recorded during the initial stages (45 days) did not show any significant change with the varying levels of irrigation given. At 75 and 120 days after irrigation, the plots irrigated daily and that at 25 and 50 per cent DASM were on par with respect to plant diameter values and were significantly superior to that at 75 per cent DASM and the unirrigated control plots. Diameter of plants irrigated at 75 per cent DASM was observed to be on par with that of unirrigated control. A similar trend was observed with respect to plant height also.

A significant difference in growth attributes (Table 5) between the irrigation levels at the end of five months was observed. The internode length was significantly higher for the daily-irrigated plants followed by the plants irrigated at 25 per cent DASM. The internode lengths for plants irrigated at 50 and 75 per cent DASM were on par and significantly higher than that for the unirrigated control plants. The unirrigated plants recorded the least value of internode length (4.7 cm). Sufficient soil moisture status is required during the shoot flush stages for maintaining the height increment in young rubber (Haridas, 1980).

Irrigation significantly increased the biomass of plants. The irrigated plants showed an increase in biomass ranging from 54 (75% DASM) to 73 per cent (daily-irrigated) over that of the unirrigated treatment. The average biomass of the unirrigated plants was only 25.8 g.

Average area of the middle leaflet also showed significant increase with irrigation.

Table 3. **Plant diameter (cm) at periodic intervals**

Treatment		Days after first irrigation			
	Pretreatment	45	50	75	150
Daily irrigation	0.42	0.58	0.74	0.93	1.12
25% DASM	0.48	0.70	0.75	0.93	1.03
50% DASM	0.47	0.62	0.76	0.91	1.01
75% DASM	0.46	0.57	0.67	0.79	0.89
Unirrigated	0.48	0.59	0.64	0.69	0.79
SE	0.02	0.02	0.02	0.03	0.04
CD (P=0.05)	NS	NS	0.06	0.09	0.12

Table 4. **Plant height (cm) at periodic intervals**

Treatment		Days after first irrigation			
	Pretreatment	45	50	75	150
Daily irrigation	53.1	71.2	90.6	114.6	135.6
25% DASM	54.3	74.1	89.2	109.6	121.7
50% DASM	58.9	77.5	95.1	110.5	119.4
75% DASM	57.9	73.5	82.7	96.1	101.4
Unirrigated	59.6	73.0	81.0	86.6	93.7
SE	2.2	2.9	3.1	4.0	4.8
CD (P=0.05)	NS	NS	9.3	12.1	14.4

Table 5. **Growth attributes of seedlings at 150 days after first irrigation**

Treatment	Number of whorls per seedling	Number of leaves per whorl	Internode length (cm)	Plant biomass (g/plant)	Middle leaflet area (cm^2)
Daily irrigation	4.7	8.0	15.9	97.0	82.2
25% DASM	4.3	6.3	11.7	80.2	77.5
50% DASM	3.7	5.7	9.7	69.7	55.0
75% DASM	2.7	5.3	9.1	57.3	50.6
Unirrigated	2.3	3.7	4.7	25.8	11.3
SE	0.34	0.63	0.23	2.27	1.73
CD (P=0.05)	1.11	2.05	0.75	7.41	5.63

Average leaflet area was 82.2 cm^2 and 77.5 cm^2 for the treatment irrigated daily and that irrigated at 25 per cent DASM, and both these irrigation levels were significantly superior to the other moisture regimes with respect to leaflet area. Leaflet area for irrigation at 50 per cent DASM (55.0 cm^2) and 75 per cent DASM (50.6 cm^2) were on par and significantly superior to unirrigated control plants, which recorded a leaflet area of only 11.3 cm^2.

From the growth parameters studied it could be inferred that under stress-free moisture conditions, there is a tendency for the seedlings to exhibit a significant increase in the growth attributes such as leaf area, number of leaves, number of whorls, internode length, plant biomass and height. However, this significant increase is not markedly reflected in the plant diameter values (Table 3). The girth of the seedlings being the single most important criterion which decides the buddability of the seedlings, it could be concluded that 50 per cent depletion of available soil moisture can be regarded as the permissible level of moisture depletion for optimum growth of rubber seedlings.

Consumptive use (CU) was worked out from the soil moisture values obtained at each irrigation interval. The values of consumptive use and crop factor (CU/Ep) at monthly intervals are given in Table 6. Consumptive use was higher for the frequently irrigated plots. For the treatments irrigated at 50 and 75 per cent DASM a lower level of CU of water was observed during March in comparison to that during February and April. This can be attributed to the lower levels of soil moisture available to the plants as evidenced by the high evaporative demand

Table 6. **Monthly consumptive use and crop factor values**

Treatment	Consumptive use (mm)					Crop factor				
	Dec	Jan	Feb	Mar	Apr	Dec	Jan	Feb	Mar	Apr
25% DASM	78.5 (4.9)	121.4 (3.9)	107.3 (3.8)	176.9 (5.7)	173.2 (5.7)	1.12	0.82	0.76	0.99	1.18
50% DASM	58.4 (3.7)	118.7 (3.8)	109.8 (3.9)	93.3 (3.0)	113.6 (3.8)	0.84	0.80	0.78	0.52	0.77
75% DASM	16.9 (1.1)	50.9 (1.6)	53.1 (1.9)	42.6 (1.4)	84.2 (2.8)	0.24	0.34	0.38	0.24	0.57

Values in parantheses represent CU per day for the month during the month. The plants may have experienced mild moisture stress during this period. However, this reduction in CU rate has not been reflected in the growth of the seedlings for up to 50 per cent depletion of available soil moisture as evidenced by the girth and plant height data (Tables 3 and 4) and the secondary growth characters (Table 5). Frequently irrigated treatments showed higher values of crop factor due to the higher rates of evapotranspiration from these plots.

The change in seasonal and daily consumptive use and the crop factor with the different regimes is given in Table 7. The seasonal consumptive use for the summer months was as high as 657.3 mm for irrigation at 25 per cent DASM. The low consumptive use in the unirrigated plots (92.2 mm) is due to the lower soil moisture available for plant growth and the poor plant canopy, which resulted in lower rates of evapotranspiration.

Table 7.**Seasonal consumptive use and crop factor**

Treatment	Consumptive use (mm)		Seasonal
	Seasonal	Average daily	crop factor
25% DASM	657.3	4.8	0.96
50% DASM	493.9	3.6	0.72
75% DASM	247.7	1.8	0.36
Unirrigated	92.2	0.7	0.14

Average daily consumptive use was highest in the treatment irrigated at 25 per cent DASM (4.8 mm/day) followed by the treatments irrigated at 50 per cent (3.6 mm/day), 75 per cent (1.8 mm/day) and the lowest by the unirrigated treatment (0.7 mm/day). The crop factor for the irrigation period was 0.96, 0.72, 0.36 and 0.14 for the treatments irrigated at 25, 50, 75 per cent DASM and the unirrigated control plots respectively.

The study indicates that rubber seedlings respond to irrigation during the dry months and 50 per cent depletion of available soil moisture is the optimum level of permissible moisture depletion for optimum growth of rubber seedlings. The 50 per cent depletion of available soil moisture corresponded to an irrigation interval of 5 to 6 days. Depletion of available soil moisture beyond 50 per cent results in growth reduction due to moisture stress.

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