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DIURNAL VARIATION IN TRANSPIRATION AND ENERGY EXCHANGE IN SOME TREE SPECIES FROM SEMI-ARID REGION

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Abstract

Diurnal changes in leaf temperature, transpiration rate, resistanaces and energy exchange were conducted in some tree species of semi-arid region. The leaf temperature in all the tree species were lower to the air temperature throughout the day except in *Bauhinia variegata* indicating no effect of transpiration on the leaf temperature in this plant. *Bauhinia variegata* and *Hardwickia binata* showed high rate of transpiration and low diffusion and stomatal resistances where as *Dalbergia sissoo* restricted waterloss from the leaf surface. The leaf energy exhange of these tree species indicate that the energy lost by radiation is more during the noon hours as compared to morning and evening hours. In general, in all tree species the most of the energy absorbed was lost by re-rediation resulted in the negative flow of convectional energy which indicate that these tree species would be able to survive in the environment with considerable high air temperature and would reduce the heat load of air. Therefore, these tree species will also help in cooling down the surrounding atmosphere and allow good under canopy growth.

Introduction

Most of the information on the seasonal and diurnal changes in water vapour exchange rate, leaf temperature, diffusion resistance and energy balance is available on the temperate mountain tree species (Purohit *et al* 1983, Bhatt. 1987) but very little information is known about the trees from semi-arid region. Since such type of study would give an idea of the adaptational behaviour of these tree species for their incroporation in the afforestaton, agroforestry and silvipastoral and range-land management programmes. The present study is an attempt in this direction on some multipurpose tree species (MPTS) of semi-arid region.

Materials and Methods

Established trees almost of the same age group of *Hardwickia binata, Albizia lebbek, Dalbergia sissoo,Ficus racemosa, Bauhinia variegata* and *Zyziphus jujuba* were selected at the experimental research farm of Indian Grassland and Fodder Research Institute, Jhansi for the present study. The observations were recorded randomly on the third leaf (from top down wards on the branches) at the full canopy growth on a clear sunny day in September - October, 1988 from 800 hr to 1600 hr at two hourly intervals. The intact leaf were mounted in the cuvette of a portable steady state porometer (Model LI -1600, LICOR, USA) with an attached quantum sensor. The trasnpiraton rate (ug/om^2/s), diffusion resistance (sec./cm), leaf temperature (^{0}C) and photosynthetically active radiation (PAR -n mole/m^2/s) were recorded simultaneously from the lower surface of the leaf. Five replications were taken for each tree species.

The stomatal resistance for water vapour transfer (rs) was calculated as water vapour partial pressure gradient/transpiration rate. The energy absorbed by leaf, the energy lost by re-radiation, the energy lost/gained by convections of heat and the energy lost by transpiration were computed for individual tree species following the derivatives of Gates (1962).

Results and Discussion

The diurnal variations in different environmental parameters are shown in Figure 1. The relative humidity (RH) decreased with increasing air temperature and photosynthtically active radiation (PAR). Maximum values of air temperature and PAR was recorded at 1400 and 1200 hours respectively whereas the lowest values was recorded during morning and evening hours. The leaf temperature in different tree species followed the pattern of air temperature but were lower to air temperature throughout the day except in *Bauhinia variegata* in which the leaf temperature was slightly higher to air temperatrue from 800 hour to 1400 hour (Table 1). The highest leaf temperature during the noon hours was recorded in *Bauhinia variegata* followed by *Hardwickia binata, Ficus racemosa* and *Dalbergia sissoo.* Several reports are available that the variations in leaf temperature is species dependent (Yarwood 1961, Lange 1965 and Purohit *et al.* 1983). In these tree species the variations in leaf temperature might be due to the differential rate of transpiraton but in *B.variegata* leaf temperature remained above the air temperature indicating that transpiration has no effect on leaf temperature in this tree species.

In all the tree species, minimum transpiration was recorded during the morning hours which increases with the increase in temperature, PAR and decrease in relative humidity during the day time reaching maximum at 1200 hour in *H.binata, Z.jujuba* and *D.sissoo* and at 1400 hour in *B.variegata* and *F.racemosa* (Table 1.). The maximum transpiration was recorded in *B.variegata* followed by *H.binata* and minimum in *D.sissoo.* The pattern of total diffusion resistance and stomatal resistance varied in different tree species (Table 2.) but in general the highest diffusion resistance was recorded at 800 hour which gradually decreased up to 1200 hour and then increased after 1400 hour. Decrease in resistance during noon hours might be due to maximum illumination of PAR (Smith and Nobel 1977). The lowest values of diffusion and stomaial resistances were recorded in *H.binata* and *B.variegata* while higher in *D.sissoo, A.lebbek* and *F.racemosa.* The higher diffusion and stomatal resistance in

Table 1: Leaf temperature and transpiration rate of different tree species

Tree species	Leaf temperature (^{0} C)						Solar time (hr) Transpiration (Mg/cm^2/ S)					
	800	1000	1200	1400	1600	Mean	800	1000	1200	1400	1600	Mean
Hardwicka binata	26.60	30.6	32.66	35.76	32.20	31.564	1.666	4.35	3.826	2.446	2.223	2.902
Albizia. lebbek	25.35	29.9	30.10	33.36	32.90	30.322	0.618	2.253	2.036	2.566	2.486	1.991
Dalbergia sissoo	25.80	31.13	34.30	33.13	31.70	31.212	0.566	1.676	1.882	1.433	1.149	1.341
Ficus racemosa	25.46	30.23	32.40	35.73	32.53	31.27	0.802	2.310	2.630	2.790	2.580	2.220
Bauhinia variegata	26.53	32.83	35.70	36.30	31.80	32.632	1.033	3.882	5.020	5.840	2.570	3.669
Zyzyphus jujuba	26.70	27.03	30.16	32.53	32.20	29.724	1.620	2.360	2.600	2.260	2.513	2.270
Average	26.07	30.28	32.55	34.47	32.22	31.12	1.051	2.805	2.999	2.889	2.253	2.399

Table 2: Diurnal pattern of resistance in different tree species

Tree species	Solar time (hr) Diffusion resistance (sec/ cm)						Stomatal resistance (Sec/ cm)					
	800	1000	1200	1400	1600	Means	800	1000	1200	1400	1600	Mean
Hardwickia binata	9.96	5.84	6.14	9.72	9.82	8.29	0.35	0.10	0.08	0.13	0.15	0.162
Albizia lebbek	15.5	9.10	8.26	8.87	9.26	10.10	1.01	0.20	0.16	0.13	0.12	0.324
Dalbergia sissoo	16.4	9.32	8.06	9.26	11.10	10.83	1.08	0.28	0.19	0.20	0.27	0.404
Ficus racemosa	10.7	9.38	9.19	8.87	8.98	9.42	0.77	0.18	0.12	0.12	0.13	0.264
Bauhinia veriegaa	13.38	6.03	5.76	5.10	9.71	7.99	0.57	0.10	0.07	0.06	0.12	0.184
Zyzyphus jujuba	9.86	6.10	5.41	9.69	9.72	8.15	0.37	0.19	0.14	0.15	0.11	0.192
Average	12.63	7.63	7.13	8.58	9.76	9.14	0.691	0.175	0.126	0.132	0.150	0.255

.hese tree species restricts maximum water loss and therefore would be tolerable to more drier environmental conditions.

The energy exchange of these tree species indicate that most of the energy absorbed was lost by re-rediation and transpiration which resulted in the negative flow of convectional energy (Table 3).

Table 3: Energy exchange (cal/cm^2/min) in different tree species

	Solar time (hr)					
Tree species	800	1000	1200	1400	1600	Mean
			Energy obsorbed			
H.binata	0.652	0.724	0.946	0.765	0.784	0.774
A.lebbek	0.625	0.748	0.863	0.773	0.785	0.758
D.sissoo	0.631	0.694	0.749	0.737	0.784	0.719
F.racemosa	0.631	0.678	0.908	0.751	0.757	0.745
B.variegata	0.649	0.812	0.974	0.821	0.705	0.792
Z.jujuba	0.657	0.743	0.825	0.736	0.853	0.763
Average	0.641	0.733	0.877	0.763	0.778	0.758
			Energy Lost by re-radiation			
H.binata	0.635	0.669	0.688	0.716	0.684	0.678
A.lebbek	0.624	0.664	0.665	0.694	0.690	0.667
D.sissoo	0.628	0.674	0.747	0.692	0.722	0.692
F.racemosa	0.625	0.666	0.686	0.716	0.687	0.676
B.variegata	0.634	0.689	0.716	0.727	0.680	0.689
Z.jujuba	0.636	0.639	0.666	0.687	0.684	0.662
Average	0.630	0.666	0.694	0.705	0.690	0.677
			Energy lost by Transpiration			
H.binata	0.023	0.061	0.288	0.042	0.122	0.107
A.lebbek	0.003	0.103	0.250	0.094	0.114	0.113
D.sissoo	0.008	0.016	0.002	0.062	0.093	0.036
F.racemosa	0.009	0.014	0.249	0.032	0.079	0.076
B.variegata	0.012	0.116	0.247	0.090	0.027	0.098
Z.jujuba	0.028	0.124	0.186	0.058	0.199	0.119
Average	0.014	0.072	0.203	0.063	0.105	0.091
			Energy lost or gained by convection			
H.binata	-0.006	-0.006	-0.030	-0.007	-0.022	-0.009
A.lebbek	-0.002	-0.019	-0.052	-0.015	-0.019	-0.021
D.sissoo	-0.005	0.004	0.000	-0.017	-0.031	-0.013
F.racemosa	0.003	-0.002	-0.027	0.003	-0.009	-0.007
B.variegata	0.003	0.007	0.011	0.004	-0.002	0.004
Z.jujuba	-0.007	-0.020	-0.027	-0.009	-0.030	-0.018
Average	-0.001	-0.006	-0.023	-0.009	-0.019	00.012

In all tree species the maximum energy lost through re-radiation was observed during the noon hours as compared to morning and evening hours. The maximum loss of energy by re-radiation and transpiration and negative flow of convectional energy caused the lower leaf temperature in most of the tree species except in *B.variegata* expressing its typical nature of adaptability. The water vapour exchange rate affects the energy budget and leaf temperature (Gates 1975) and also influences the surroundings (Ludlow 1987). Therefore, it is concluded that due to negative flow of convectional energy and maximum loss of energy through reradiation and transpiration, these tree species would be able to survive at high thermal load and would reduce the heat load of surrounding area through cooling effect which will create congenial environment for fast under canopy growth.

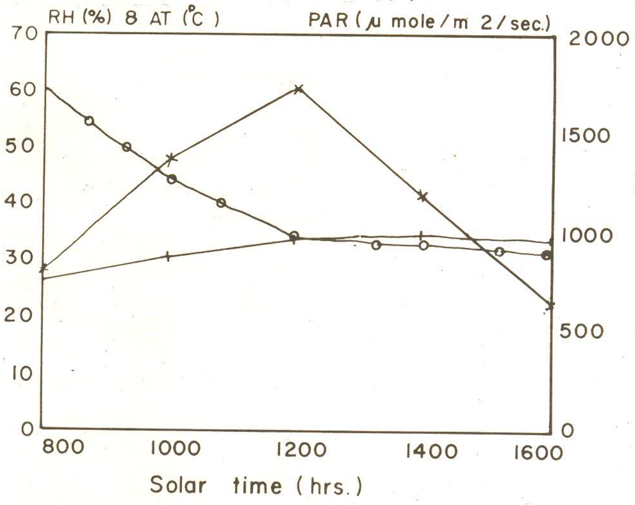

Fig.1: Diurnal pattern of RH (%, 0---0) Air Temperature (AT°c,----) and Photosynthetically active radiation (PAR/u mole/m²/s, x----x).

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