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TRANSPIRATION AND STOMATAL CONDUCTANCE OF GRASS SPECIES UNDER *LEUCAENA* BASED SILVIPASTORAL SYSTEM

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Abstract

The variation in canopy temperature (CT) and photosynthetically active radiation (PAR) transmission under the trees of *Leucaena leucocephala* L. and transpiration rate, stomatal conductance, diffusion resistance and leaf temperature of grass species (viz. *Cenchrus ciliaris, Panicum maximum* and *Dichanthium annulatum* were studied under silvipastoral system in semi arid region. Results showed that the rate of transpiration, leaf temperature and stomatal conductance of grasses were reduced under the tree canopies than the open field whereas diffusion resistance for water vapour transfer increased. The rate of transpiration and stomatal conductance were higher during the noon hours both in open and under tree canopies. The canopy temperature of *L. leucocephala* decreased 5.4^{0}C below the air temperature. The transmission of PAR through the *Leucaena* canopies was recorded only 20 to 25 per cent. Due to minimum reduction in transpiration and stomatal conductance in *C. ciliaris* and *Dichanthium annulatum,* these grass species may be considered suitable for *Leucaena* based silvipastoral system.

Introduction

The growth and productivity of a plant is related to its functional interactions with the surrounding and also on the speed of readjustment under a particular set of environment. The adaptational potential can be determined by rate of photosynthesis, transpiration and water use efficiency. The water vapour exchange rate affects the temperature and energy budget of a leaf and consequently the physiology of whole plant (Gates 1975). This physiological process in the silvipastoral system mainly governed by the under canopy micro-environmental changes. Large variation have been observed in micro-environmental parameters under the tree canopies and particularly in light transmission and temperature (Misra and Bhatt 1993, Hazra and Tripathi 1985). Keeping in view the adaptational and functional behaviour of a plant species in the tree-crop intercropping system, it is now realized to study the environmental changes for sustainable system. In the silvipastoral system the functional processes of grass species received very little attention and require extensive investigation. Therefore, the present study was undertaken to work out the light transmission and canopy temperature of *Leucaena leucocephala* and their interaction to the physiological phenomenon

occurring in grasses (viz. *Cenchrus ciliaris, Panicum maximum* and *Dichanthium annulatum*).

Materials and Methods

The trial was conducted under ten year old silvipastoral system of *Leucaena leucocephala* (Lam.) de Wit. in semi arid region at Central Research Farm of IGFRI, Jhansi. Three grass species (viz. *Cenchrus ciliaris* L., *Panicum maximum* Jacq. and *Dichanthium annulatum* Forsk were grown under the *Leucaena* trees and in open field. The spacing between tree to tree and row to row were 4 x 5m and between the two rows of grasses was 50 cm. After two years of establishment of grasses the observations were recorded at flowering stage of grass at two hours interval from 8 to 16 hours on a clear sky day in September 1991 and 1992. The light transmission through tree canopies and canopy temperature were recorded by Radiometer/Quantum meter (LI- 188) with attached line quantum sensor and Infrared thermometer (Ag-42) respectively. For the measurement of transpiration, diffusion resistance and leaf temperature, intact fully grown leaf was mounted in the cuvette of a portable steady state porometer (Model LI-1600 LICOR, USA). Three observations from each replication from different places of the field were taken for each species. The stomatal conductance for water vapour transfer (s) was derived from 1/stomatal resistance. The stomatal resistance was calculated as water vapour partial pressure gradients/transpiration rate.

Results and Discussion

Variation in air temperature (AT), canopy temperature (CT) and photosynthetically active radiation (PAR) in open field and under *Leucaena leucocephala* canopies are shown in figure -1. Maximum air temperature and PAR were recorded at 14

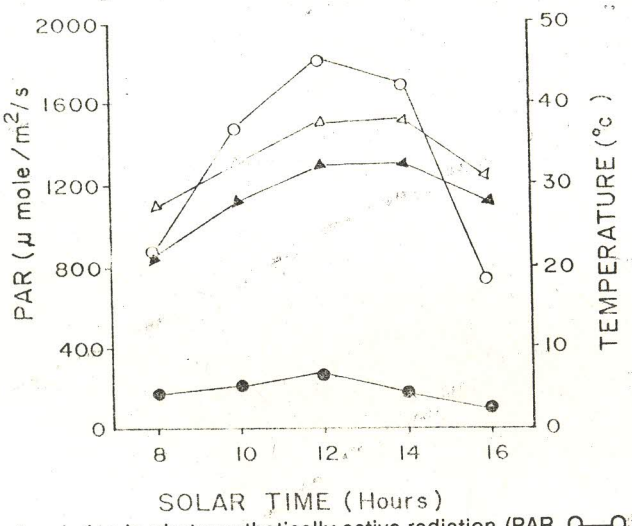

Figure -1 : Diurnal variation in photosynthetically active radiation (PAR, O—O), PAR transmission under L. Leucocephala canopies (O—O), air temperature (AT, Δ—Δ) and canopy temperature (CT, Δ—Δ)

Table 1 : Leaf temperature and stomatal conductance for water vapour transfer in different grass species under *L. leucocephala* and in open field condition.

Grass species	Canopy	Leaf temperature (^{0}C) Solar time (hrs)						Stomatal conductance (rs')solar time (hrs.)					
		8	10	12	14	16	Average	8	10	12	14	16	Average
C. .ciliaris	Open	29.6	32.1	33.7	35.1	33.1	32.72	10.19	10.20	14.14	18.26	6.27	11.81
	Tree	28.9	30.4	32.0	33.2	31.4	31.18	5.73	5.85	8.21	8.66	3.53	6.39
P. maximum	Open	29.8	31.2	32.8	33.6	30.5	31.58	10.74	10.8	12.65	15.33	7.01	11.30
	Tree	29.1	29.7	30.7	32.0	29.5	30.2	4.01	5.49	7.11	8.29	2.67	5.51
D. annulatum	Open	29.5	31.7	33.5	34.5	32.1	32.26	9.99	10.37	18.10	20.05	9.60	13.62
	Tree	29.1	30.8	32.4	33.7	31.6	31.52	5.09	5.03	9.75	12.12	5.42	7.22
Average	Open	29.63	31.66	33.33	34.4	31.90	32.18	10.30	10.45	14.96	17.88	7.62	12.24
	Tree	29.03	30.30	31.70	32.96	30.83	30.96	4.94	5.45	8.36	9.69	3.87	6.46

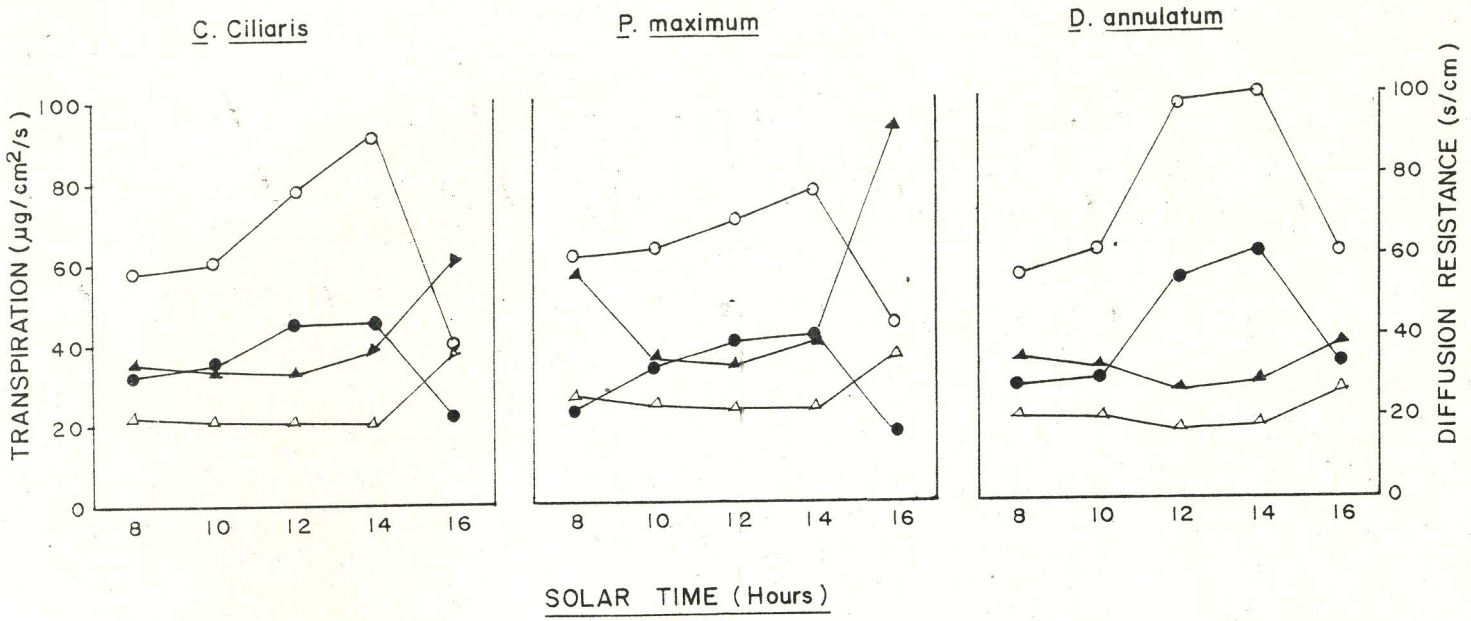

Figure -2 : Rate of transpiration and diffusion resistance in C. ciliaris, P. maximum and D. annulatum under L. leucocephala trees and in open field conditio n (Transpiration open, O—O, under tree O—O ; dissusion resistance - open Δ—Δ , under tree Δ—Δ).

and 12 hours respectively and minimum values in morning and evening hours. The temperature under *Leucaena* trees was lower as compared to open field and this reduction in temperature may be due to decrease in radiation. The canopy temperature of *Leucaena* trees was lower to air temperature and maximum value of CT-AT difference (-5.4^0C) was recorded at 12 and 14 hours. The radiation reaching the grasses was obviously reduced under the shading of tree canopies. The PAR transmission through *Leucaena* tree canopy was observed only 20 to 25 percent of total PAR at fully grown canopy in 4 x 5 m spacing.

The diurnal changes in leaf temperature of different grass species followed the pattern of air and canopy temperature. In General, leaf temperature of all the grasses were lower under tree canopies compared to the grass grown in open field condition (Table-1). The highest leaf temperature was recorded in *C. Ciliaris* leaves followed by *D. annulatum* and *P. maximum.* The differences in leaf temperature might be due to species variation in transpiration rate and particularly under tree canopies and it is influenced by temperature and radiation. The leaf temperature is species dependent and similar findings were also reported by Yarwood (1961), Lange (1965), Purohit *et al.* (1983) and Bhatt *et al.*, (1991).

In all the grass species studied, higher rate of transpiration was recorded during noon hours and lowest at 8 and 16 hours respectively (Fig. 2) There was greater reduction in transpiration rate of grasses under tree canopies than that in open field. In general in all the grasses transpiration decreased upto 50 per cent under the canopies of *L.leucocephala* and this reduction might be due to decrease in temperature, PAR and also by partial closure of stomatal pore under shade. Decreasing PAR and AT adversely affects the relative humidity, stomatal conductance and, therefore, water vapour exchange decreased. The stomatal conductance for water vapour transfer also followed the same path of transpiration but the lowest stomatal conductance was observed at 16 hour. This reduction in stomatal conductance of grasses under tree canopies caused the lower transpirational loss of water vapour from the leaf surface.

The highest diffusion resistance (DR) was recorded in all the grasses under tree canopies as compared to open (Fig. 2). Maximum DR was also observed in all the grass species in open and under tree canopy of *Leucaena* at 8 to 16 hours and minimum at 12 hours. The decrease in diffusion resistance during noon hours occurred due to higher illumination (Smith and Nobel 1977) through which the stomatal opening takes place and stomatal resistance decrease which ultimately lowers the total diffusion resistance.

The rate of transpiration is mostly dependent on PAR, temperature and stomatal conductance and a positive significant correlation with these parameters is observed in the present study (Table 2). Similarly the stomatal conductance is found significant correlation with leaf temperature and available PAR whereas diffusion resistance is negatively correlated with these parameters. This highly significant correlation amongst these parameters is suggestive of the fact that these physiological process are mainly influenced by microenvironment available under silvipastoral system.

Table 2 : Correlation coefficient (r) among various parameters

Parameters	TR	DR	rs'	LT	PAR
Transpiration (TR)	1.000				
Diffusion resistance (DR)	-.81.1 $^{1.0}$	1.000			
Stomatal conductance (rs')	.992 $^{0.1}$	-.783 $^{1.0}$	1.000		
Leaf temperature (LT)	.768 $^{1.0}$	-.432	.792 $^{1.0}$	1.000	
Photosynthetically active radiation (PAR)	.917 $^{-.1}$	-.734$^{2.0}$	.870$^{0.1}$	.614 $^{5.0}$	1.000

(Values over the figures indicating the percent significance)

Therefore, the minimum decrease in transpiration rate and stomatal conductance in *Cenchrus ciliaris* and *Dichanthium annulatum* under tree canopies indicates their adaptability towards low light intensity for optimum growth and productivity under *Leucaena* based silvipastoral system in semi-arid region.

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