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Photosynthesis and biomass studies in *Lasiurus sindicus* of Chandan grassland in Thar Desert

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Introduction

Grasslands comprise about one third of the world's area of natural vegetation (Adams *et al.*, 1990). Uncertainties prevail in the arid ecosystem with reference to carbon balance and fluxes which are primarily attributed to the sensitivity of grasslands to variation in annual precipitation, temperature and other regulating mechanisms of eco-physiological processes (Flanagan *et al.*, 2002). It is therefore necessary to study radiation and water use efficiency of *Lasiurus sindicus* which is a predominant grass species in Chandan grassland of Thar desert to understand and evaluate its growth in relation to variation in climate. Also, it is pertinent to resolve whether grassland ecosystem function as a source or sink to atmospheric CO_2. We therefore, measured diurnal variability of net photosynthesis, diurnal trend in light and water use efficiency and root and shoot biomass studies (10 days interval) of *L. sindicus* (*Sewan*) grass species in relation to ambient micrometeorological conditions during growth period along three points *viz.*, initial, peak and declining phenophase to have basic understanding of eco-physiological responses to prevailing micrometeorology to evaluate its carbon use efficiency.

Materials and Methods

Present study was conducted at Central Arid Zone Research Institute (CAZRI) experimental area at Chandan ($26^{o}50.83^{/}$N, $71^{o}18.083^{/}$E) near Jaisalmer, covering ≈96 hectares of grassland ecosystem predominantly consisting of *Lasiurus sindicus* locally known as *Sewan* grass (≈60%) with associated grass species *viz.*, *Cenchrus ciliaris* (≈15%) and *Panicum antidotale* (≈5%). The climatic conditions are characterized by highly variable precipitation (≈100-300 mm), extremes of temperatures (48^{o}C in summer and -3^{o}C in winter), high wind speed (≈33kmh^{-1}) high insolation and thus leading to very high evaporative demand. The soil texture is sandy with low organic carbon content and low fertility status. The phenology of the *Lasiurus sindicus* varies (Plate 1) as the beginning of the growing season during south-west monsoon (Mid of July-August end), followed by good green grass growth in post-monsoon season (September - Mid of October) and senescence phase in winter (3rd week of October to – January end).

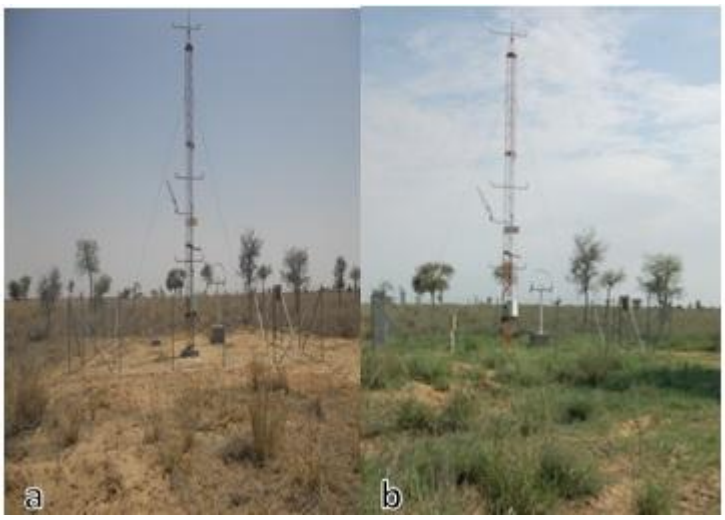

Plate. 1: Pre - (a) and post-monsoon (b) phenology of *L. sindicus* grass species in the study area

The leaf area index (LAI) was measured at 10-day interval from the growth initiation (greening) phase from the first dekad of July (Jul 1d). The LAI measurements lasted up to senescence (browning) phase. The LAI measurements were taken using plant canopy analyzer (LAI-2000; Li-Cor, Inc., Lincoln, NE). In each quadrat, the mean LAI was obtained by taking average of eight readings. Mean LAI of all the quadrats were computed to represent the temporal dynamics of LAI. Leaf level photosynthesis (*Lnar*) data was acquired using Li-Cor's LI-6400XT portable photosynthesis system was upscaled to canopy level according to Campbell and Norman (1998) assuming single light assimilation response relation for all the leaves in the canopy. Biomass of *L. sindicus* was collected in 3 replicates in 1x1m quadrats at every 15 days interval through destructive method from 2nd Week of April to 3rd week of August from $1m^2$area using permanent iron quadrats. Fresh weights of both shoots and roots were taken using digital balance and the dry weights after keeping them in oven at 55^o C for 24 hours.

Results and Discussion

During initial phenophase of new leaf initialization, leaf level photosynthesis (*Lnar)* of *L. sindicus* was measured in daytime with an average of 6.4 µmols CO_2 $m^{-2}s^{-1}$. LAI of *L. sindicus* species was also minimum at 0.65. Canopy level photosynthesis (*Cnar*) noted approximately half to that of *Lnar* as *LAI* was minimum. At peak growth phenophase, *Lnar* of *L. sindicus* was at life cycle maximum with an average of 8.3µmols $CO_2m^{-2}s^{-1}$. *LAI* at this phase of growth was 1.75. At this time *Cnar* was about 20-35 per cent higher than *Lnar*. At senescence phase, with decline in soil moisture regime and unfavorable winter conditions, *L. sindicus* reached physiologically dormant state. This was manifested in declining LAI (0.8) and degreening of leafs in grass. During dormant stage an average *Lnar* was found 3.2 µmols CO_2 $m^{-2}s^{-1}$ and *Cnar* was 20-25 per cent lower than *Lnar*, as LAI decline. *L. sindicus* exhibited bimodal distribution in its diurnal photosynthetic rates with its first peak (13 to 15 µmol $CO_2m^{-2}s^{-1}$) at about 10 Indian Standard Time (IST) and second but higher peak (18 to 20 µmol $CO_2m^{-2}s^{-1}$) at around 16 hrs. The maximum light use efficiency ($2.73gMJ^{-1}$) was around 10 and 16IST with occasional dip ($0.47\ gMJ^{-1}$) at around 14IST (Fig. 1).

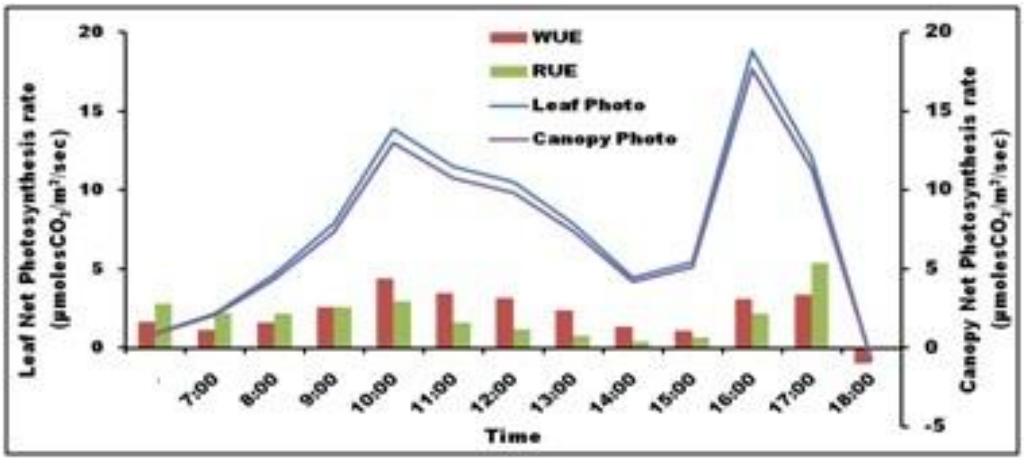

Fig. 1: Eco-physiological responses (Diurnal) of *L. sindicus* during peak growth stage

Stomatal closure was affected by extreme temperature and atmospheric forcings could be the cause for the dip in photosynthesis rate during noon hours. Daytime peak canopy CO_2 exchange rate in the present study is comparable to that obtained by eddy covariance system in semiarid environment of south India (Lalrammawia and Paliwal, 2010). The diffuse fraction was also found to have sharp bimodal trend (15-51%) with peaks in the morning and late afternoon which might have contributed to observed peaks in photosynthesis (Zhang *et al*., 2009). During evening hours after setting of declining limb of winter condition, with decrease in daylight hours, L_{nar} turned negative, *i.e.,* respiration exceeded photosynthesis rate. The *L. sindicus* showed maximum water use efficiency (WUE) during morning and evening hours. Consequently, light use efficiency (LUE) *L. sindicus,* showed similar trend *viz.,* minimum ($0.43gMJ^{-1}$) during noon hours and peaks (2.96, 2.03 gMJ^{-1}) at morning and afternoon hours (Fig 1). Combination of higher diffuse fraction and lower ambient temperatures in the morning and afternoon hours in contrast to noon hours might have resulted into generalized bimodal trend in the *LUE* of *L. sindicus*. Biomass studies of *L. sindicus* (*Sewan*) grass species indicates that average shoot and root weight is 296 and 414 gm/m^{-2} respectively. Biomass studies and related analyses showed that *L. sindicus* acted as a carbon sink to atmospheric CO_2 and has fixed carbon to about 3.20 tons per hectare.

Conclusion

The study concludes that at the initial and final phenophase in the life cycle of *L. sindicus*, leaf level assimilation rate is greater than that of canopy level. Diurnal trend of photosynthesis, LUE and WUE exemplifies the adaptation strategy of this grass species. Stomatal closure in *L. sindicus* during peak day time hours controls net carbon assimilation and transpiration. *L. sindicus* grass species in Chandan grassland acted as a carbon sink to the atmospheric CO_2 and has the ability to ameliorate the extreme climate in Thar desert region through fixation of carbon in vegetation and soil.

References

Adams, J. M., H. Faure, L. Fauredenard, J. M. Mcglade and F. I. Woodward. 1990. Increases in terrestrial carbon storage from the last glacial maximum to the present. *Nature* 348: 711–714.

Campbell, G. S. and J. M. Norman. 1998. *Introduction to Environmental Biophysics*. Springer Science + Business Media Inc., New York, USA.

Flanagan, L. B., L. A. Wever and P. J. Carlson. 2002. Seasonal and inter annual variation in carbon dioxide exchange and carbon balance in a northern temperate grassland. *Global Change Biology* 8: 599–615.

Lalrammawia, C. and K. Paliwal. 2010. Seasonal changes in net ecosystem exchange of CO_2 and respiration of *Cenchrus ciliaris* L. grassland ecosystem in semi-arid tropics: an eddy covariance measurement. *Current Science* **98:**1211-1218.

Zhang, M., G. R. Yu, L. M. Zhang, X. M. Sun, X. F. Wen, S. J. Han and J. H. Yan. 2009. Impact of cloudiness on net ecosystem exchange of carbon dioxide in different types of forest ecosystems in China. *Biogeo sciences Discussions* 6: 8215–8245.

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