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Diurnal changes in chlorophyll fluorescence in four species of bamboo

RAKESH KUMAR [1], MOHINDER PAL [1,*] and U. V. S. TEOTIA [2]

[1] *Plant Physiology Discipline, Forest Research Institute, Dehra Dun, 248 006, India*
[2] *Doon College of Agriculture, Science and Technology, Camp Road, Selakui, Dehra Dun, Uttaranchal 248 006, India*

Abstract—Diurnal changes in chlorophyll fluorescence characteristics in leaves of four bamboo species (*Guadua angustifolia, Bambusa tulda, Dendrocalamus giganteus* and *Dendrocalamus strictus*) grown under nursery conditions were recorded in June 2001. Photochemical efficiency of photosystem (PS) 2 measured as F_v/F_m ratio, varied with species and with the time of observation. Absolute parameters of chlorophyll fluorescence (F_0, F_m and F_v) and F_v/F_m ratio were increased significantly from morning (1000 h) to afternoon (1600 h) in all species. *G. angustifolia* and *B. tulda* showed midday depression in F_v/F_m ratio at 1400 h while the other two species showed only constant values of F_v/F_m ratio for one hour. Hence, the chlorophyll fluorescence characteristics and midday depression in F_v/F_m ratio is species specific.

Key words: Chlorophyll; fluorescence.

INTRODUCTION

Bamboo is one of the most versatile multipurpose woody plant species. It is one of the fastest growing species and is attracting the attention of plant physiologists for elucidation of the factors contributing to the fast growth. Of late, numerous studies have been taken up, world over, to determine photosynthetic efficiency of different plant species using the chlorophyll fluorescence method [1–3]. Understanding of photosynthetic efficiency in bamboo is an important step in this direction.

When a leaf is illuminated at constant intensity it will fluoresce at a steady level. However, if a leaf is kept in darkness for several minutes and then is brightly illuminated, fluorescence rapidly rises from a low-level (F_0) via an intermediate level to a peak level (F_m) and then gradually decays through several intermediate

*To whom correspondence should be addressed. E-mail: palm@icfre.org or sajwalr@yahoo.com; Website www.geocities.com/sajwalr/index.html

maxima to a level close to the original F_0 level. It is important to note that the size of the fluorescence signal is directly proportional to the intensity of the illumination.

The difference between the maximal fluorescence signal (F_m) and the low level signal (F_0) is said to be the variable component of fluorescence (F_v). The calculated ratio of F_v/F_m has been shown to be proportional to the quantum yield of photochemistry [4] and shows a high degree of correlation with the quantum yield of net photosynthesis of intact leaves [1].

The work on the photosynthetic efficiency of plants using chlorophyll fluorescence studies has been done in many species [3], but in bamboo this is a new dimension for workers. The studies on chlorophyll fluorescence can give a fair idea of productivity and suitability of a suitable species for cultivation under a given area. These studies may help in developing a criterion for selection and evaluation of species and provenances.

The present study was conducted on four species of three genera of bamboo, to assess the diurnal changes in chlorophyll fluorescence parameters. An attempt was also made to determine the comparative photosynthetic efficiency of these bamboo species.

IMPLICATIONS OF THE STUDY

The objective of the study was to test the comparative efficiency and diurnal changes in chlorophyll fluorescence parameters of different bamboo species. The results indicate that various bamboo species behave photo synthetically different and on the basis of present findings all four bamboo species can be divided into two groups. In one group, *B. tulda* and *G. angustifolia* and in another group *Dendrocalamus* spp. can be placed. Findings of the present study may help in selection of different species for an environment. For example, *Dendrocalamus* spp. are not susceptible to high irradiances while *B. tulda* and *G. angustifolia* are less susceptible; so, *Dendrocalamus* spp. are more suitable for tropical environment than *B. tulda* and *G. angustifolia.*

Actually we could not find any report on bamboo, so we compared our findings with other species. Joshi [3] has reported diurnal changes in about 12 dicot species, out of which some species showed late reduction and fast recovery. The report of Joshi supports the present study as *B. tulda* and *G. angustifolia* showed a similar trend. Though the results of different plant systems should not be matched or compared, as bamboo plant has some special characteristics, the non-availability of literature on bamboo bound us to shift onto other species.

MATERIAL AND METHODS

Plants

Four species of bamboo (*Gigantochloa angustifolia, Bambusa tulda, Dendrocalamus giganteus* and *Dendrocalamus strictus*) growing in the experimental area of

Plant Physiology Branch of Forest Research Institute, Dehra Dun (30° 20′ 40″ N latitude, 77° 52′ 12″ E longitude and 640.08 m altitude) were selected for the present study. Plants were grown from offsets and planted in bags containing about 50 kg forest soil. All plants were propagated from mature clumps and planted one year before the observations. These were grown under the normal environmental conditions prevailing at New Forest. The soil moisture was maintained at field capacity level by frequent irrigation.

Chlorophyll fluorescence measurements

Young fully expanded leaves (third or fourth leaf from the apex of the mid lateral branch) of plants were darkened with leaf clips for 20 min (as this time for the length of dark adaptation was found appropriate) before the measurement of Cl fluorescence characteristics (F_0 low level fluorescence; F_m maximum fluorescence; F_v variable fluorescence; F_v/F_m photochemical efficiency of photo system 2 measured with a portable Hansatech Plant Efficiency Analyzer from Hansatech, King's Lynn, UK). Measurements were made at 1 h intervals from 1000 to 1600 h on sun exposed leaves. Three plants from each species and 3 leaves from each plant were selected for measurements of chlorophyll fluorescence. Observations were recorded on the 25th June and repeated on 26th June 2001. Mean of the observations recorded on both days were calculated and the data was statistically analysed using SPSS (Statistical Package for Social Sciences) which helps in data analysis.

Environmental parameters

The environmental conditions prevailing during the study period are given in Fig. 1.

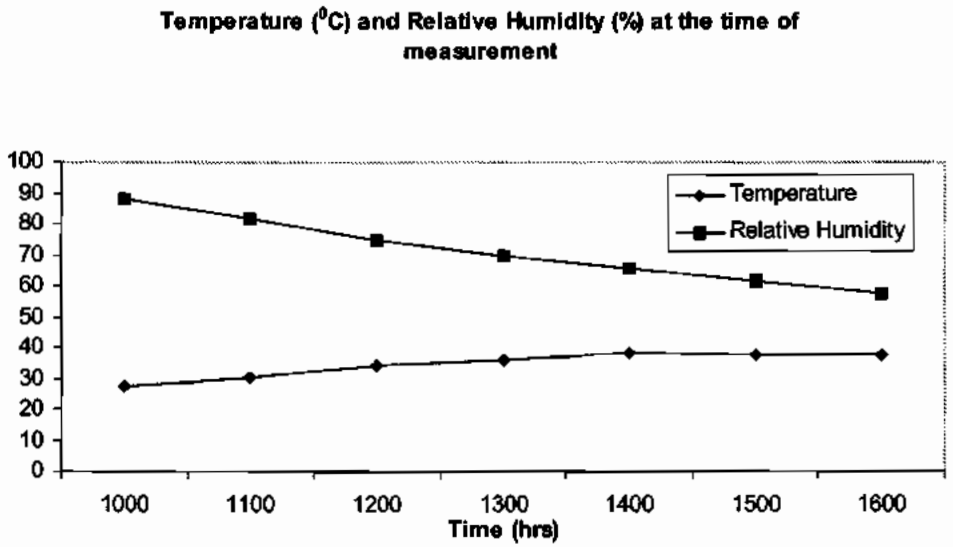

Figure 1. Diurnal change in aerial temperature and relative humidity.

RESULTS AND DISCUSSION

Data on diurnal variation in F_0, F_m, F_v and F_v/F_m are presented in Figs 2–5..No specific trend was observed in absolute fluorescence parameters (F_v, F_m and F_v) with time or species. Generally the values of these parameters increased with time, which may be due to increase in temperature or irradiance or both. In general, a

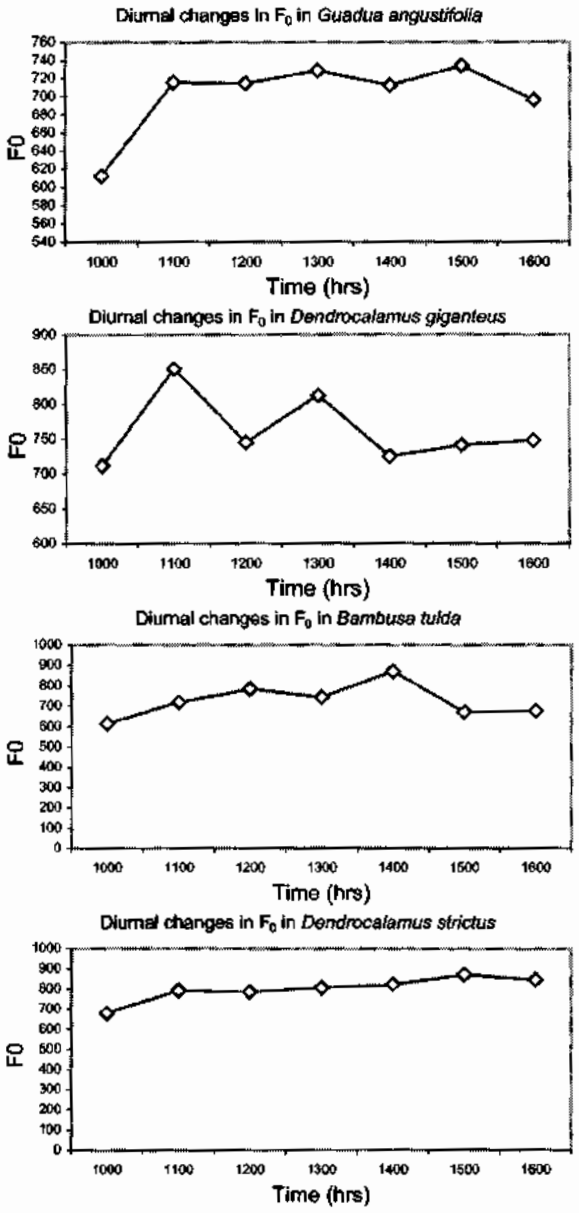

Figure 2. Diurnal variation in minimal fluorescence (F_0) in different species.

decline in all these absolute parameters was observed at 1400 h in all species but in *D. strictus* the decline was observed at 1500 h.

In general, F_v/F_m increased significantly in all species from 1000 h onwards. Maximum value of F_v/F_m (0.76) was recorded in *G. angustifolia* followed by *B. tulda* (0.75), while minimum (0.71) was recorded in both species of *Dendrocala-*

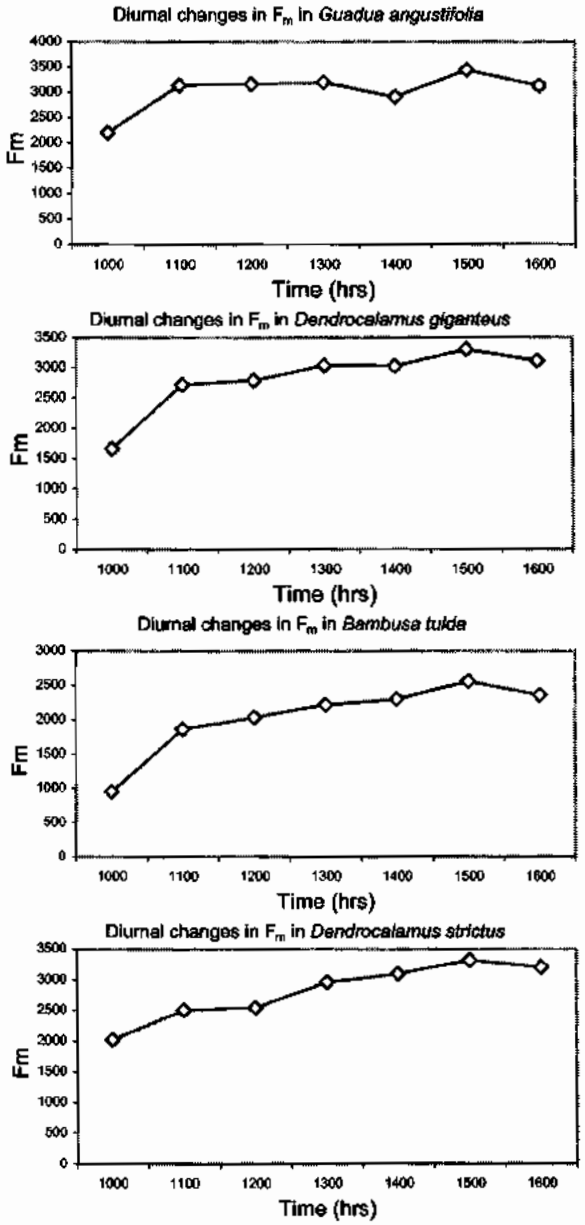

Figure 3. Diurnal variation in maximal fluorescence (F_m) in different species.

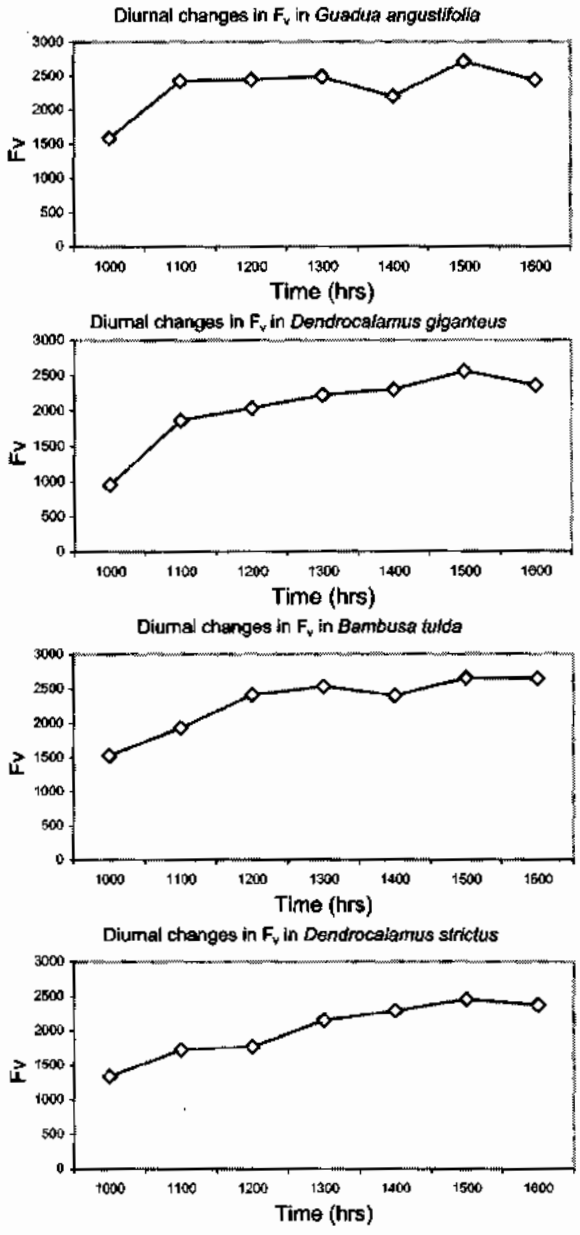

Figure 4. Diurnal variation in variable fluorescence (F_v) in different species.

mus (Fig. 5). It indicates that the efficiency of different bamboo species in fixing the atmospheric carbon varies with time and species.

G. angustifolia and *B. tulda* exhibited mid-day depression at about 1400 h on photochemical efficiency of PS 2 (F_v/F_m) which was followed by fast recovery by 1500 h. In the other two species constant values of F_v/F_m were recorded for an

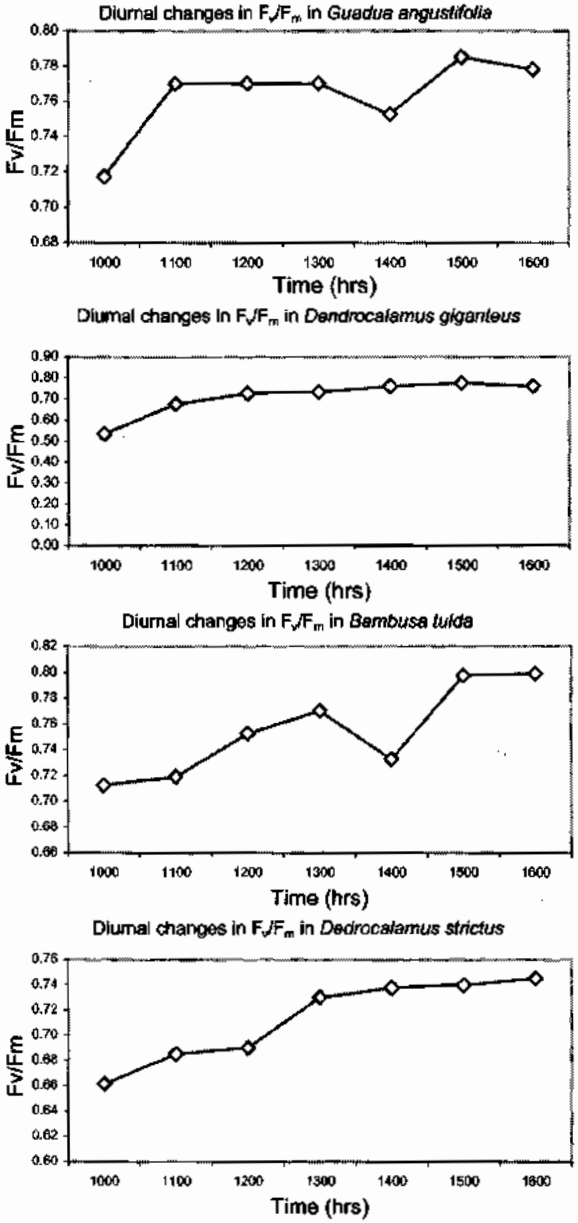

Figure 5. Diurnal variation in photochemical efficiency (F_v/F_m) in different species.

hour (1200–1300 h in *D. giganteus* and 1100–1200 h in *D. strictus*) although there was no clear-cut mid-day depression in the photochemical efficiency of PSII.

Diurnal changes in chlorophyll fluorescence of different plant species has also been reported by other workers [2, 3]. It is also reported that around midday, the photosynthetic capacity in plants under field conditions declines during summer due

to photo-inhibition [5–12]. The photo-inhibitory quenching, q_1 is related to damage caused by excessive light energy and has a half-life of about 40 min. This quenching results from increased non-photochemical processes and is detected as a decrease in F_v/F_m following exposure of leaves to bright light. It correlates with a loss of quantum yield of photosynthesis. Probably q_1 is related to damage to the D_1 protein of PSII caused when the energy load on the system is excessive [13].

The late reduction (1400 h) and fast recovery showed that these species (*B. tulda* and *G. angustifolia*) are less susceptible to high irradiances (Fig. 5). Joshi [3] has also reported maximum decline in F_v/F_m ratio between 1200–1400 h in most of the species that he used in his study. (Joshi has reported other observations as well, but we are only concerned here with his report on late reduction and fast recovery). Similar observations were reported by Kao and Tsai [14] in *Kandelia candel*. Therefore, selection of bamboo species/provenances/clones not showing and/ or showing minimum midday depression may be of advantage for yield improvement programs in bamboo.

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