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## RESEARCH ARTICLE

# EFFECT OF ENHANCED SOLAR UV-B (280-320NM) RADIATION ON PHOTOSYNTHETIC ELECTRON TRANSPORT ACTIVITY OF SOME PLANTS AT DIFFERENT GROWING SEASONS

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**ABSTRACT**

Depletion ozone layer and fluctuation of UV-B radiation on the earth's surface is a most common phenomenon for last few decades. The potential impact of solar UVB radiation studied in three legume plants (Black gram, Cluster bean, Green gram) in field condition at two different seasons like summer and winter. The first season is (summer) coupled with dry weather and high temperature (35-40°C) and the second (monsoon) with rainy and slightly low temperature (28-32°C). The ambient UV-B levels in both seasons vary only marginally. The chlorophyll fluorescence induction kinetics are used to study the photosynthetic electron transport activity of the both ambient and UVB -treated plants.So the fast fluorescence transients give an overall picture of the early electron transport reactions. Enhanced UV-B radiation did not affect Fo values in all the three species. In *Cluster bean*, the UV-B radiation significantly affected the Fv/Fm ratio in both the season. Such reduction was very high in monsoon season than summer. This indicates a reduction in PSII efficiency and possible inhibition of energy transfer within the PSII reaction center. In *Black gram* UV-B radiation increased the Fv/Fm ratio in both the season. Whereas in green gram no change was noticed.This could be due to high proportion of light harvesting matrices per reaction centre



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## INTRODUCTION

The ozone layer act as a filter for the shorter wavelength and highly hazardous ultraviolet radiation from the sun, protecting the life on earth's from its potentially harmful effect. The CFC and other contributing substance deplete the ozone layer and it increases UV radiation in the biosphere especially UVB radiation in the range of the280-320nm increasing on the earth's surface. This is a most common phenomenon for past few decades. A number of studies have been carried out to investigate the effect of the enhanced UVB radiation on plants .But very few studies only reported about the seasonal changes of UVB on plants. The incidence of UVB radiation varies by season a with winter time increase as high 35% per year, while there is 9.7% in summer (Kerr and Mcclory 1993; Solomon 1990).

This enhanced exposure of UVB is potentially vulnerable to plant. Because due to lack of locomotion of plants. The effect of UVB on plants included inhibition of growth, morphology changes (Sharma *et al*., 1998; Hollosy, Brzezinska 2006, Wargent *et al*., 2011), productivity and other physiological process. In the physiological process, the photosynthesis is a more sensitive function compare to other process. The UVB radiation destroys the photosynthetic pigment and damage the chloroplast with potential impairment of electron transport, photophosphorylation and carbon fixation. It mainly affects PSII in the thylakoid membrane, specifically the functionality of the D1 protein, decreasing the electron transport (Boooji *et al*., 2002, Januskaitiene, 2015). The Chl a fluorescence measurement study have been used to study the electron transport activity in plants. The UVB radiation diminished PSII efficiency it indicates the inhibition of electron transport in plants and its reduced maximal photochemical efficiency of PSII (FV/FM) (Szollasi *et al*., 2008; Hui *et al.,* 2016).

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For this studies chlorophyll-a fluorescence can be used to detect inhibition of photosynthetic electron transport in plants exposed to the enhanced UVB at two different seasons. The first season is (summer) coupled with dry weather and high temperature (35-40$^{o}$C) and the second (monsoon) with rainy and slightly low temperature (28-32$^{o}$C).The ambient UV-B levels in both seasons vary only marginally.

## MATERIALS AND METHODS

### Plant materials

Certified seeds of *Vigna mungo* L (T9), *Vigna radiata* L (KM2) and *Cyamopsis tetragonoloba* L. (Pusa navbagar) obtained from the Agriculture Department, Madurai were sown in experimental plots in the Madurai Kamaraj University Botanical Garden. One set of plants was grown under ambient solar radiation and other under 20% UV-B enhanced solar radiation.

### Plant growth and UV-B treatment

The seeds were soaked overnight in running water. Separate soil beds were prepared for control (ambient) and UV-B treatment and seeds were sown in these experimental plots. The plants were watered regularly and care was taken to avoid microbial or pest infection during the experimental period. Plants with the first foliage leaf stage were used for UV-B treatment. UV-B treatment was given to these plants for 4 hours daily from 10 a.m to 2 p.m. Treatment was continued under ambient solar radiation and 20% UV-B enhanced solar radiation supplemented by a Philips TL40W/12 sunlamp (Gloelampenfabrieken, Holland). The first formed trifoliate leaves were collected at different time periods and all the physiological analyses were carried out. Experiments were carried out in two seasons, one during the month of March-May (summer) and second during September-January (monsoon). The experimental plots were maintained for three years (2001-2004) continuously without any disturbance.

### Weather report

All weather data were collected from the University weather station.

### Fluorescence transients

Chl a fluorescence induction was followed in intact leaves after excitation with broad band blue light (400-520 nm, Corning CS4-96). The irradiance at the sample surface was 100 W.m$^{-2}$. The photomultiplier (Hamamatzu, R376) placed at 90˚ to the excitation beam, was protected by an interference filter (λ max 690 nm, half band width 12 nm Schott, Germany). The signal from the photomultiplier was displayed on a Iwatsu model SS-5802 digital oscilloscope (Iwatsu Corp., Japan).

## RESULTS

Chlorophyll-a fluorescence is a rapid method for measuring photosynthetic electron transport from plants in vivo, and it requires very little sample preparation. Stimulation of fluorescence from chlorophyll-a in photosystem II (PSII) reaction centres under different light conditions produces several parameters, each describing the efficiency of a photochemical reaction or process within the photosynthetic apparatus. The variable fluorescence ratio Fv /Fm,which describes the maximum efficiency of PSII photochemistry.The changes in fast fluorescence transients were followed with leaves of ambient and enhanced UV-B radiation grown plants (Fig. 1and 2).

Typical fluorescence induction shows a rapid rise to Fo level followed by a slow one reaching the maximum level (Fm) after about 600 ms. The level of slow variable part (Fv) differed in these three species grown under ambient and UV-B enhanced radiation. In the case of *Cluster bean* a reduction in Fv had occurred in UVB treated plant compare to ambient plant. When compared to summer season the monsoon season showed a reduction in Fv level and a slow induction.

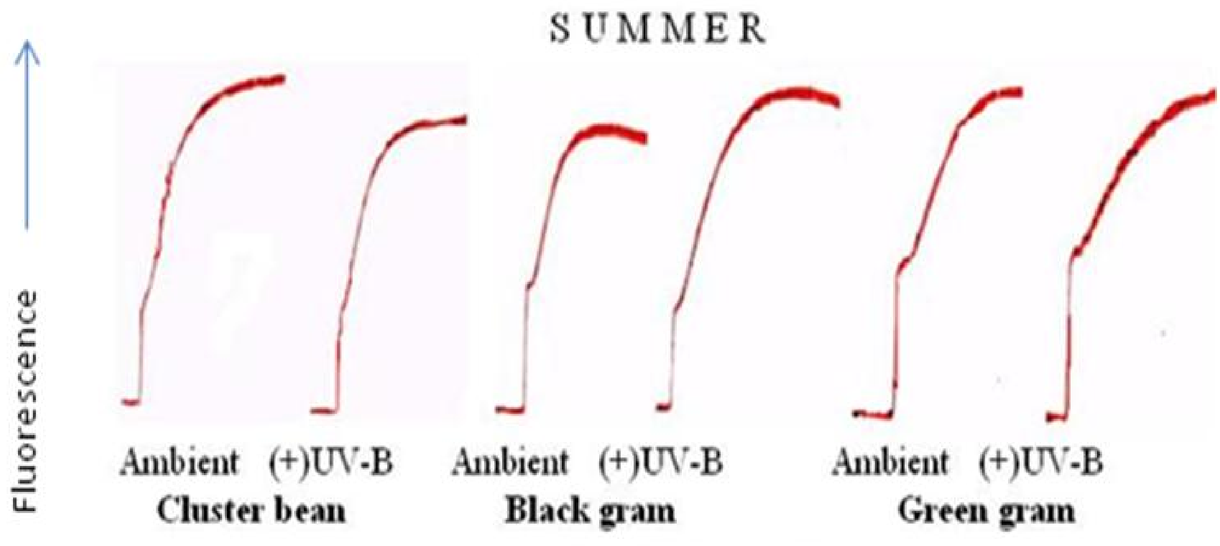


**Fig.1.Typical fast fluorescence induction curve of Cluster bean,Black gram and Green gram plants grown under ambient and enhanced UV-B radiation in summer seasons. The leaves were incubated in the dark for 10 min prior to excitation**

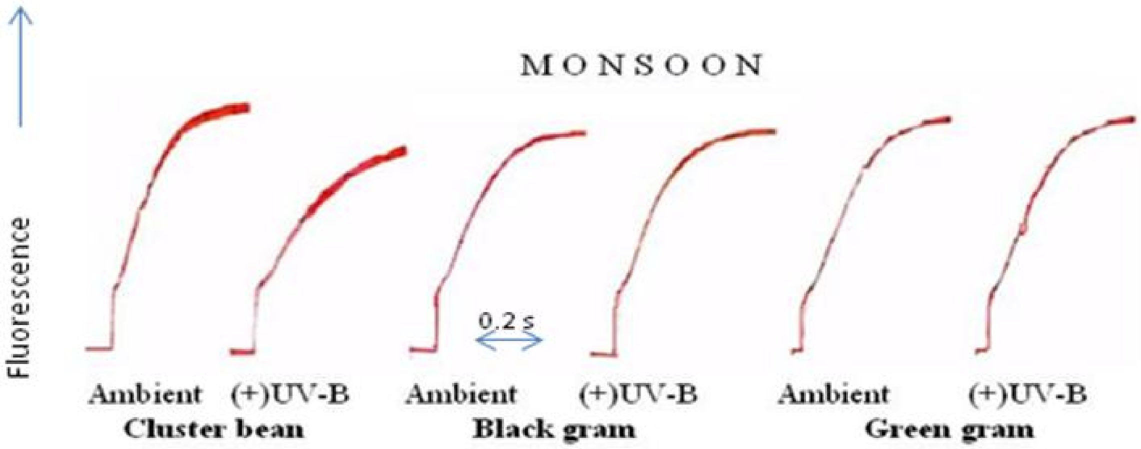


**Fig. 2. Typical fast fluoresence induction curve of Cluster bean,Black gram and Green gram plants grown under ambient and enhanced UV-B radiation in monsoon seasons. The leaves were incubated in the dark for 10 min prior to excitation**

Where as in *Blackgram* the enhanced UVB radiation increase the FV/FM ratio. Such induction was very high in summer season than monsoon. In the case of *Green gram* the level of Fv did not show any difference between the ambient and UV-B treated plants but the Fv change was slowed down in the later case.

## DISCUSSION

Changes in Chl a fluorescence are the best probe in tracing out the primary photosynthetic events and also in monitoring the plant responses to any environmental stress affecting the photosynthetic capacities (Smillie, 1983). The Fo values were unaffected in all three species. High Fo observed in UV-B treated *Helianthus annus* cotyledons was notably due to reduced excitation transfer in the antennae or to an increase in the antenna cross section (Mark and Tevini, 1997). In *Cluster bean* UV-B radiation produced a significant reduction in variable fluorescence in both the season. The decline in Fv/Fm indicates a reduction in the potential PSII efficiency (La Porta *et al*., 2004). The PSII is the first step in photosynthetic electron transport, inhibition of electron transport anywhere within the electron transport chain excerts excitation pressure on PSII, which can be detected as diminished Fv/Fm (Huner *et al*., 1998).Tevini and Iwanzik (1983) observed a progressive reduction in variable fluorescence yield with the increase in the UV-B level. The reduction in the variable fluorescence indicates a possible inhibition of energy transfer within the PSII reaction centre (Kulandaivelu and Noorudeen, 1983, Melis *et al*., 1992). In addition, variable fluorescence can be used as an internal probe for measuring the redox state of PSII electron acceptor, $Q_A$ . The ratio between Fv and Fm is lowered by the UV-B irradiation which causes damage on the thylakoid and produces structural changes in D1/D2 polypeptide complex (Renger *et al*., 1986). The degradation of $Q_B$ protein under UV-B radiation has also been reported. However, a change in the stoichiometric ratio of PSII and PSI has also been proposed (Lingakumar and Kulandaivelu, 1993). The diminished Fv/Fm can indicate a large proportion of inactive PSII reaction centres due to oxidation or degradation of theD1 protein. (Anderson, 1997) La Porta *et al*., (2005) reported that the variable to maximum Chl fluorescence (Fv/Fm) is a measure of the potential efficiency of PSII and the electron transport mechanism. Recently Stroch *et al*. (2015) revealed the UVA exposure barley plant exposed to UVB radiation itself led to reduction in potential quantum yield of photosystem II(PSII) photochemistry(Fv/Fm)the capacity of light induced thermal energy dissipation and the efficiency of excitation energy transfer with in PSII. UV-B stress promoted an increase in minimal fluorescence of dark-adapted state (F0) and F0/Fm, and a decrease in variable fluorescence (Fv, Fv/Fm, Fv/F0 and F0/Fm) due to its adverse effects on photosystem II (PSII) activity (Ranjbarfordoei *et al*., 2011) Changes in the fluorescence parameters were observed also in Mosses and Lichens (Csintalan *et al*., 2001) bean (Kreslavski *et al*., 2001), and young and mature needles of *Cypress* (La Parota *et al*., 2004). Somersalo and Krause (1990) and Schnettger *et al*. (1994) showed a relationship between the Fv/Fm and PSII electron transport activity in thylakoids isolated from photoinhibition needles. Bouchard *et al*. (2005) reported a decline in the Fv/Fm ratio under high UV-B radiation due to the absence of D1 repair.A Higher level of Fv was found in *Black gram* and there was no change in *Green gram*. This could be due to the stabilized photosynthetic apparatus by reorganization of the thylakoid components. (Wargent *et al*., 2011). Lichtenthaler *et al*. (1982) showed that chloroplast with higher and broader stacks will have higher levels of LHCPs which are associated with higher ground fluorescence. UV-B was also increased, in addition to higher maximum photochemical efficiency of photosystem II (PSII) (Fv/Fm) was reported in *Lactuca sativa.* Shreiber *et al*. (1977) and Fork and Govindjee (1980) also reported the high Fv/Fm due to the high proportion of light harvesting matrices per reaction centre.

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